

# **Finite Element Analysis of Offshore Oil Platform IRENE**

**Final Report**

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Laurel, Maryland 20707**

## **Final Report**

# **Finite Element Analysis of Offshore Oil Platform IRENE**

### **Acknowledgement**

**The work reported here is performed for the  
Mineral Management Service under the technical  
direction of Mr. Charles Smith**

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## **1.0 INTRODUCTION**

The structural response of off-shore oil platforms to wind and wave loading is a necessary input in the design process. This response is developed by testing already constructed platforms and correlating the data with finite element models to develop adequate modelling methods. In addition, this process can be reversed where the results of the finite element analysis can be used to determine where to locate the measuring instrumentation to pick-up the maximum response during testing. It is this latter procedure that is the subject of this report.

Off-shore oil platform IRENE, located off the California coast at Santa Barbara, is scheduled to be instrumented with accelerometers to determine the horizontal and vertical deck response to a horizontal load. The platform is a jacket type construction with two main decks, a sub-deck and a small deck just above the waterline.

A detailed finite element model of the platform was constructed using the MSC/NASTRAN finite element code. This model proved too large to run and so was reduced using symmetry boundary conditions and coarser modelling. A description of both models including illustrations detailing grid point and element numbering is presented in the following section. The reduced model was subjected to an eigenvalue/eigenvector analysis with the resulting information used in a unit random response analysis. Results presented include frequencies and their corresponding mode shapes as well as random loading response of selected points on the two main decks and the sub-deck.

## **2.0 FINITE ELEMENT MODELING**

Two finite element models of platform IRENE were constructed. The first was a detailed model of the structural members of the platform. The resulting eigenvalue analysis proved too unwieldy and the model was replaced with a simpler model. The simpler model utilized one quarter of the detailed model by assuming two planes of structural symmetry. Both models are discussed in more detail in the following paragraphs.

### **2.1 Detailed Finite Element Model**

The detailed finite element model of platform Irene (see Figure 1) included the jacket, drilling deck, production deck, sub-deck, elev (+) 15 deck, and deck connections. The following sections contain descriptions of the construction of each of these components. Also included are schematics showing grid and element numbering, boundary conditions, and coordinate system definitions as well as tables showing element properties.

#### **2.1.1 Jacket**

The jacket portion of the model consists of Rows A, B, 1, 2, 3, & 4 as detailed on Dwgs 03-SS-03-0 thru 03-SS-08-0. Grid and element numbering are shown on Figures 2 thru 7. Also shown are the support points at grids 100, 120, 400, and 420. Table 1 groups the elements with the appropriate beam properties.

### **2.1.2 Elev (+)15' Deck**

Grid and element numbering for the elev (+)15' deck are shown in Figure 8. The out of plane members (Dwg 03-SS-09-0) were ignored. Table 2 groups the elements with the appropriate beam properties.

### **2.1.3 Drilling Deck**

Grid and element numbering for the drilling deck are shown in Figure 9. The deck (Dwg 03-SS-50-0) was modelled as a uniform continuous structure, with the presence of hatches, etc., ignored. In other words, the W21 x 57 cross beams were assumed to run continuously from one side to the other. Table 3 groups the elements with the appropriate beam properties.

### **2.1.4 Production Deck**

The production deck (Dwg 03-SS-51-0) was modelled similar to the drilling deck. Grid and element number are shown in Figure 10. Table 4 groups the elements with the appropriate beam properties.

### **2.1.5 Deck Connections**

The deck connections (Dwg 03-SS-56-0 thru 03-SS-61-0) grid and element numbering are shown in Figures 11 thru 16. Table 5 groups the elements with the appropriate beam properties.

### **2.1.6 Sub-deck**

As shown in the grid and element numbering in Figure 17, only part of the sub-deck (Dwg 03-SS-52-0) was included in the model. The part left out was ignored since it would not contribute significantly to the global stiffness of the platform. Figures 18 and 19 illustrate the grid and element numbers connecting the sub-deck to the production deck as defined in Dwg 03-SS-55-0. Table 6 groups the elements with the appropriate beam properties.

## **2.2 Symmetric Finite Element Model**

The symmetric finite element model of Platform IRENE (see Figure 20) consists of a reduction of the detailed modelling utilizing two planes of symmetry in the modelling of the jacket, drilling deck, production deck, sub-deck, elev (+)15' deck, and deck connections and simplifying the drilling and production decks. The symmetry assumption is not entirely correct, since the sub-deck occurs only in the positive x-y plane, however, it was deemed necessary to achieve a solution to the model. The boundary conditions at the two planes of symmetry consisted of fixing all rotations and the displacement normal to the symmetry plane. The following sections contain descriptions of the construction of each of these components. Also included are schematics showing grid and element numbering, boundary conditions, and coordinate system definitions as well as tables showing element properties.

### **2.2.1 Jacket**

The positive x-y plane contains half of jacket Rows B, 1, & 2. Grid and element numbering are shown on Figures 21 thru 23. Also shown are the support point at grid 420. Table 7 groups the elements with the appropriate beam properties.

### **2.2.2 Elev (+)15' Deck**

Grid and element numbering for the elev (+)15' deck are shown in Figure 24. Table 8 groups the elements with the appropriate beam properties.

### **2.2.3 Drilling Deck**

Grid and element numbering for the drilling deck are shown in Figure 25. Only the main beams of the deck were included. Table 9 groups the elements with the appropriate beam properties.

### **2.2.4 Production Deck**

The production deck was modelled similar to the drilling deck. Grid and element number are shown in Figure 26. Table 10 groups the elements with the appropriate beam properties.

### **2.2.5 Deck Connections**

The deck connections grid and element numbering are shown in

Figures 27 thru 29. Table 11 groups the elements with the appropriate beam properties.

### **2.2.6 Sub-deck**

The grid and element numbering of the sub-deck is shown in Figure 30. Figures 31 and 32 illustrate the grid and element numbers connecting the sub-deck to the production deck. Table 12 groups the elements with the appropriate beam properties.

### **2.2.7 Finite Element Model Results**

The results presented in the following paragraphs include a listing of the platform eigenvalues, plots of selected eigenvectors and acceleration response PSD's of selected points on the platform decks when subjected to random vibration input.

### **2.2.8 Platform Eigenvalues**

Table 13 lists the 68 eigenvalues extracted from the model between 0 and 20 hz. Note that these eigenvalues correspond to symmetric eigenvectors.

### **2.2.9 Platform Eigenvectors**

Figures 33 thru 56 are plots of selected eigenvectors. The eigenvectors were chosen based on the participation of the decks. Accelerometers placed at the point of maximum excursion on the decks will measure the corresponding frequencies.

### **2.2.10 Platform Response to Random Excitation**

The finite element model was subjected to a unit random load between 0 - 20 hz in the x direction at the water line. Selected acceleration PSD's at grid points located on the deck are shown in Figures 57 thru 68. These curves are representative of the accelerations expected at these points when the platform is instrumented and tested.

### **3.0 CONCLUSIONS**

Results presented for the symmetric model include frequencies and their corresponding mode shapes up to 20 hz and random loading response of selected points on the two main decks and the sub-deck. The selected points constitute locations where accelerometers should be positioned during the testing phase. The response plots are indicative of the expected accelerometer readings. At the conclusion of the test, the finite element model will be updated to match the test data.

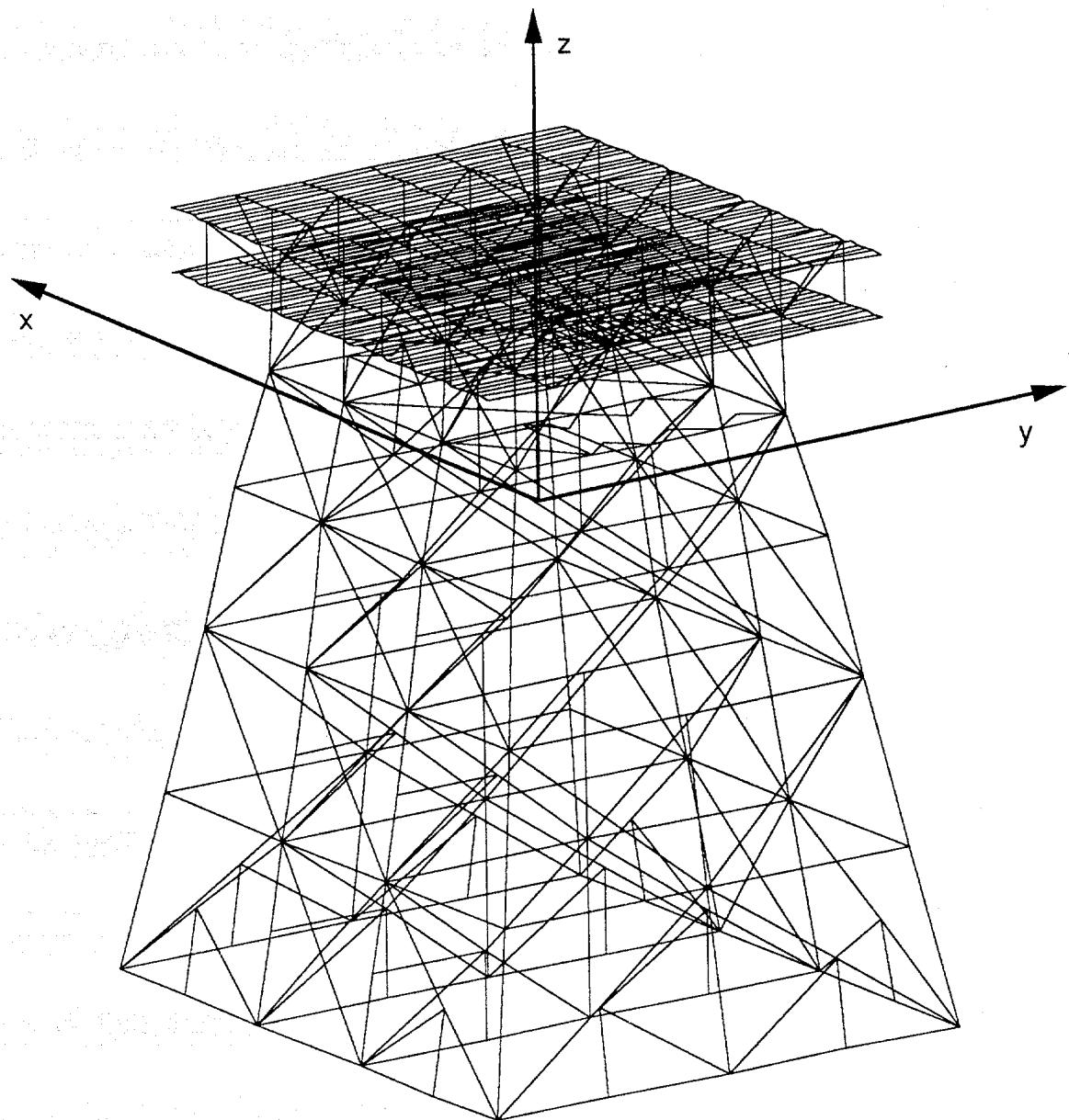


Figure 1 - Detailed Finite Element Model of Platform IRENE

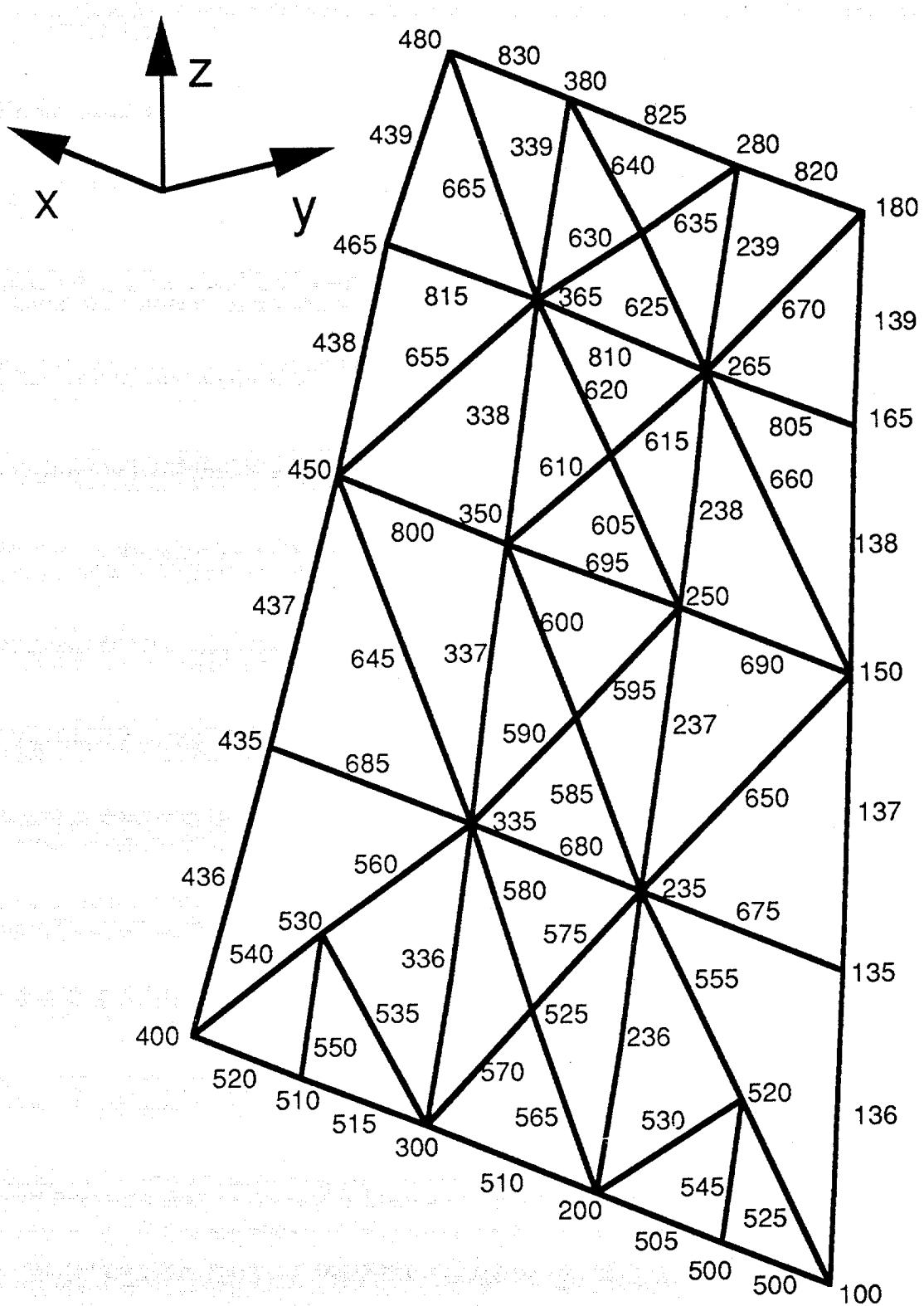


Figure 2 - Jacket Row A Element and Grid Point Numbers

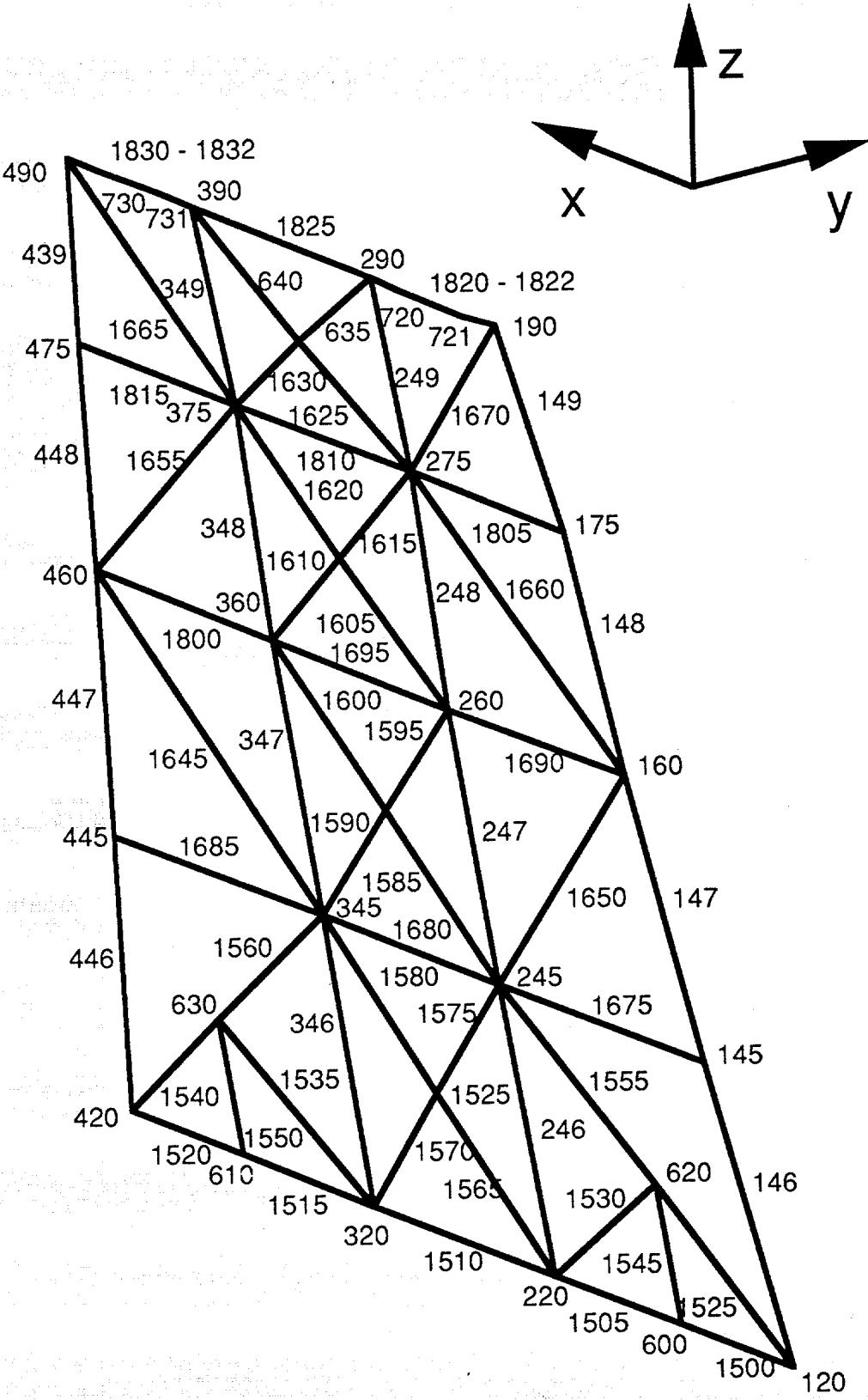


Figure 3 - Jacket Row B Element and Grid Point Numbers

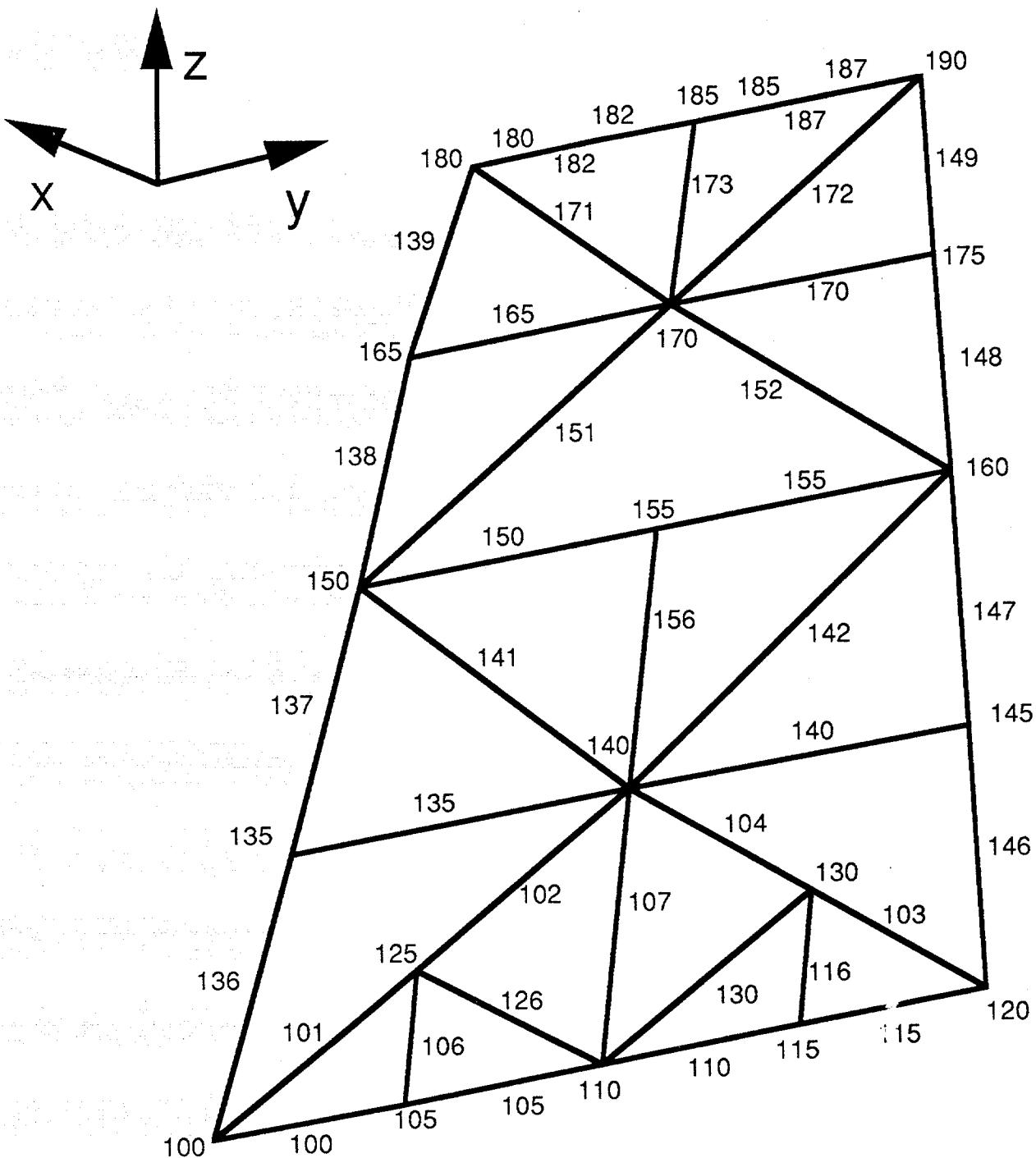


Figure 4 - Jacket Row 1 Element and Grid Point Numbers

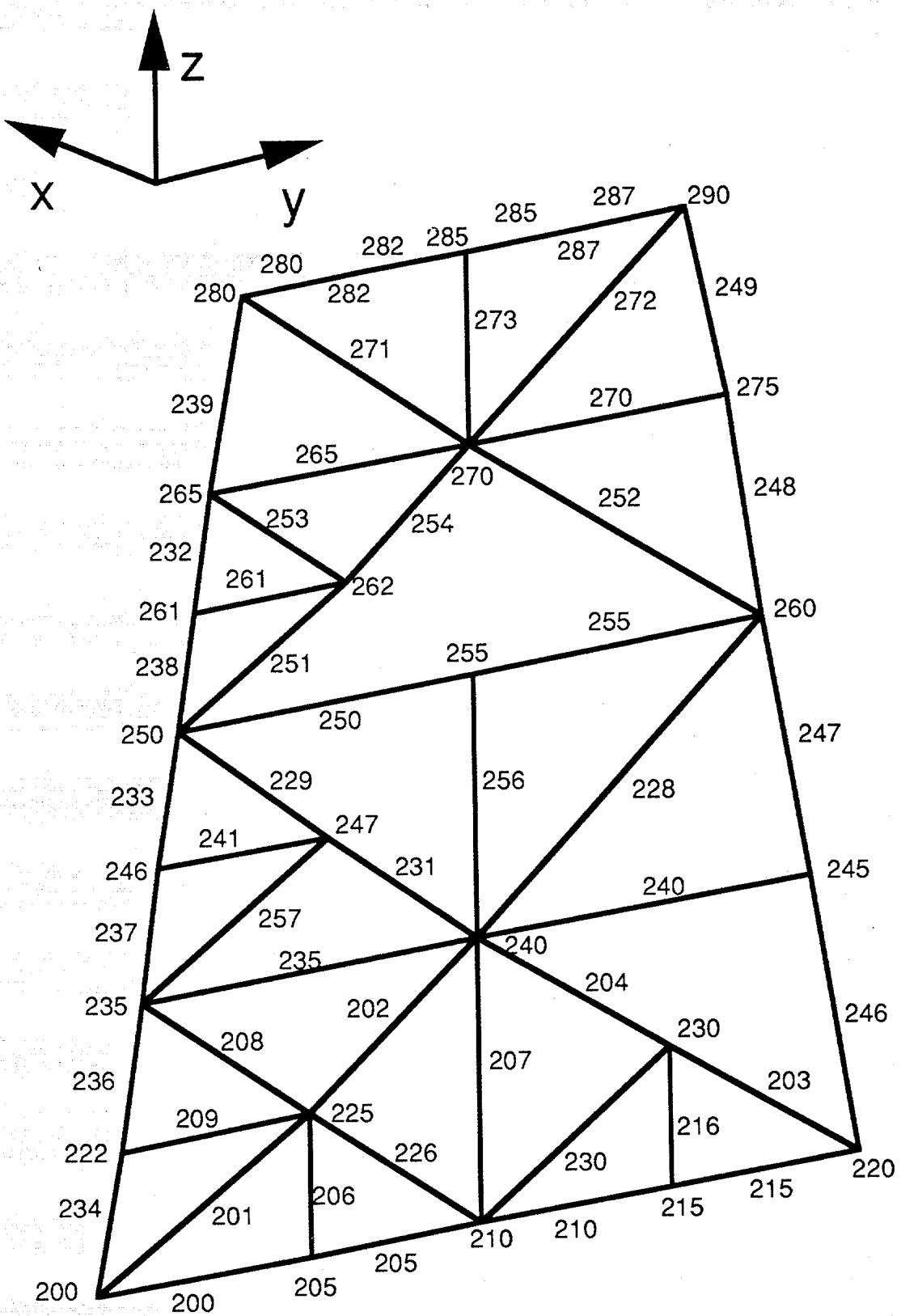


Figure 5 - Jacket Row 2 Element and Grid Point Numbers

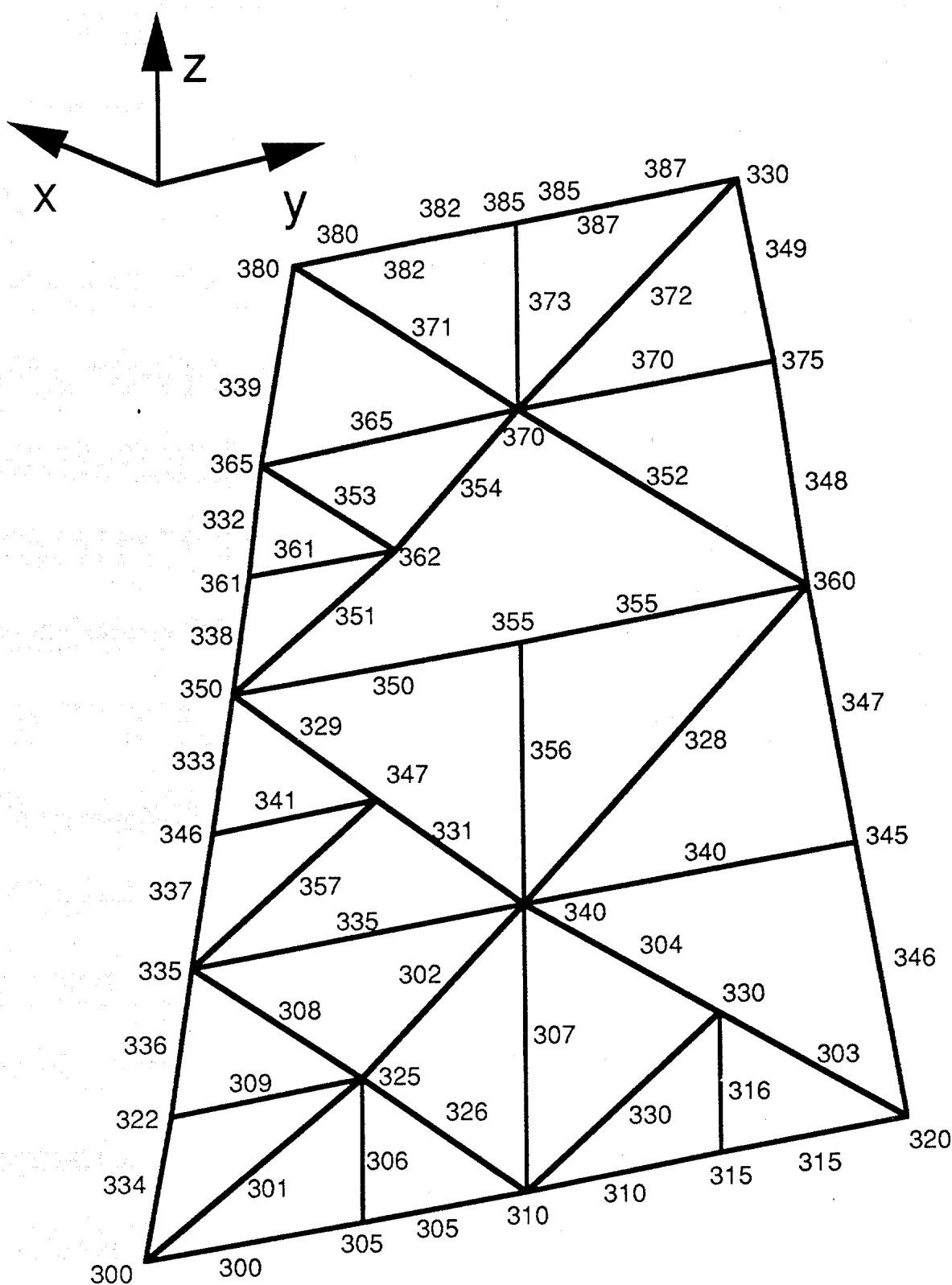


Figure 6 - Jacket Row 3 Element and Grid Point Numbers

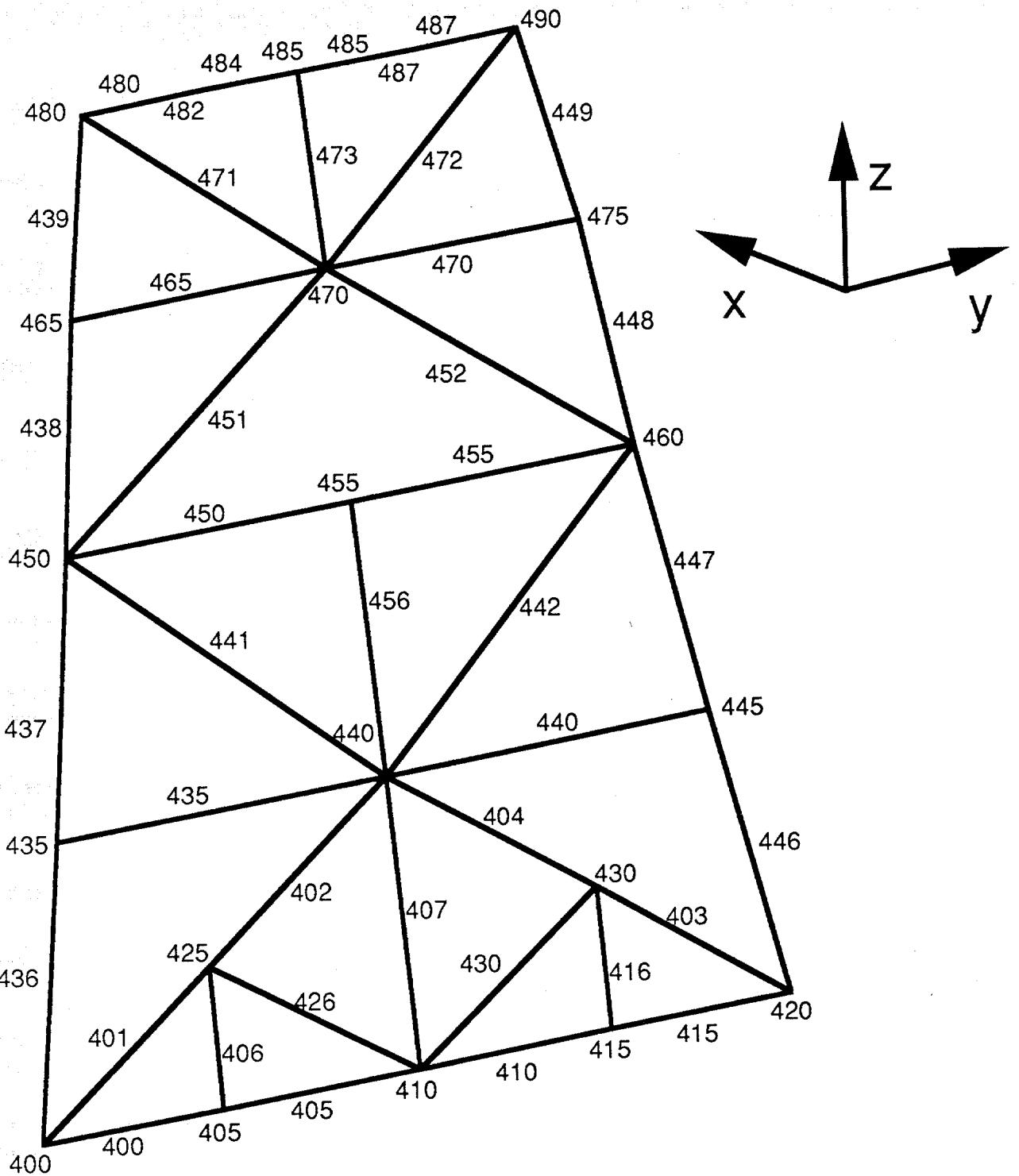


Figure 7 - Jacket Row 4 Element and Grid Point Numbers



Figure 9 - Drilling Deck Element and Grid Point Plot

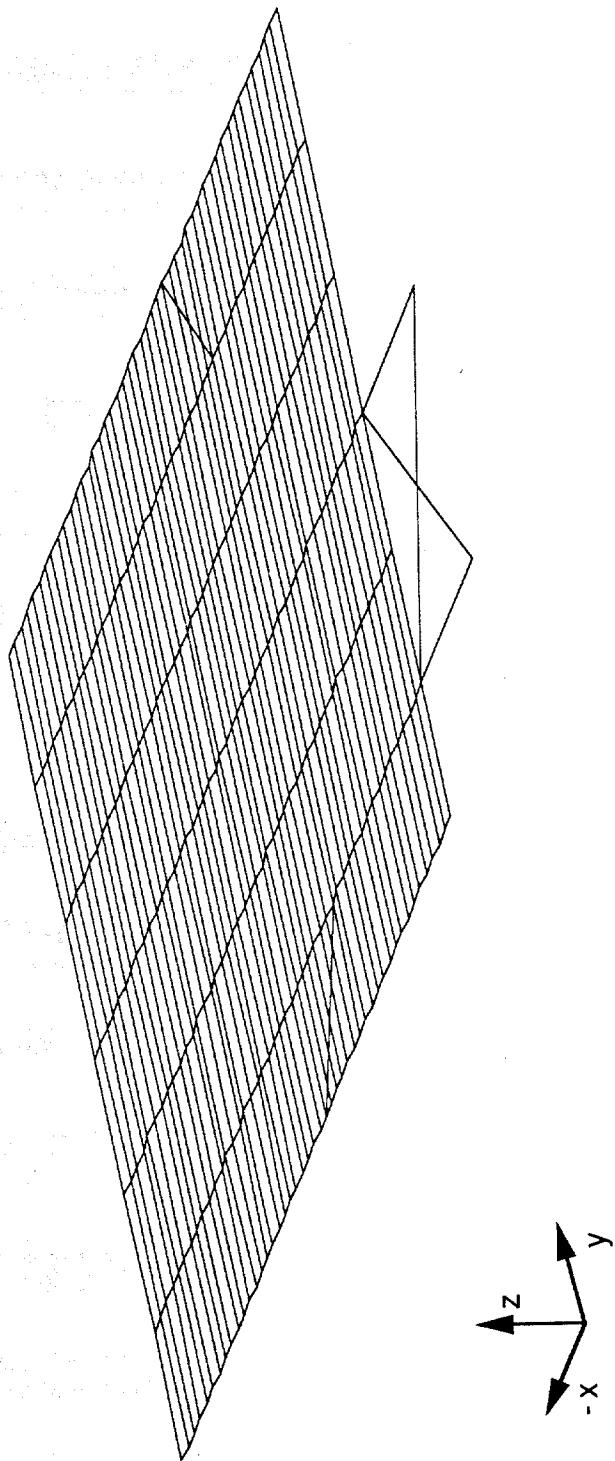


Figure 10 - Production Deck Element and Grid Point Plot

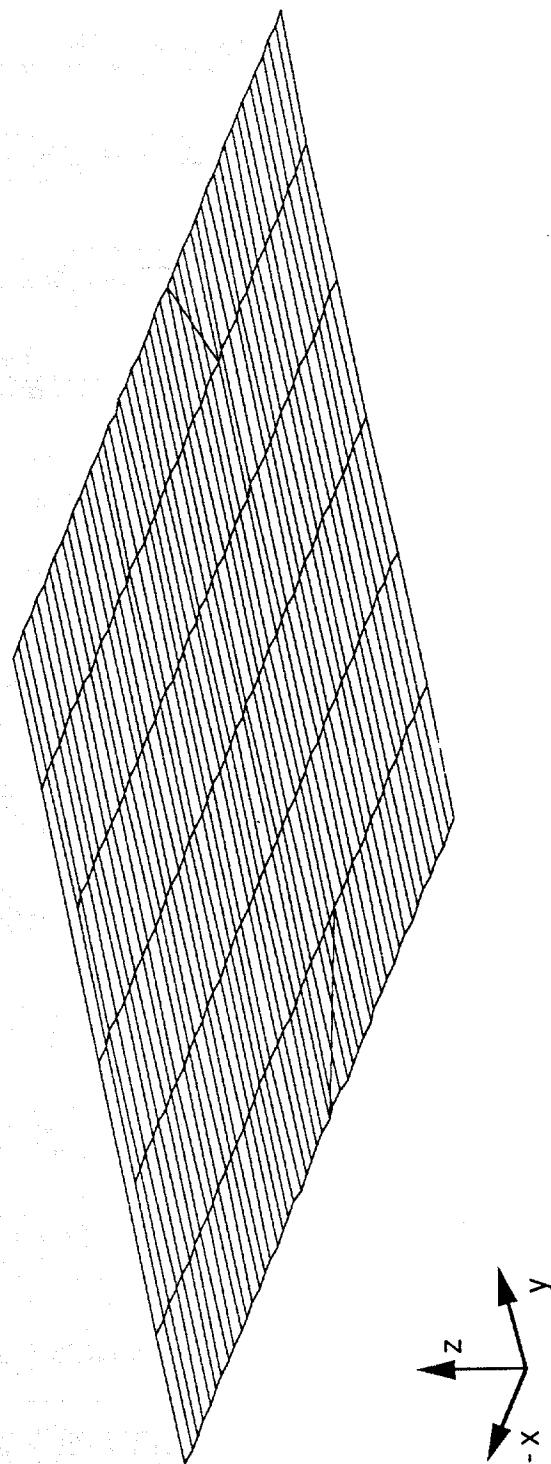


Figure 11 - Row A Elevation Element and Grid Point Numbers

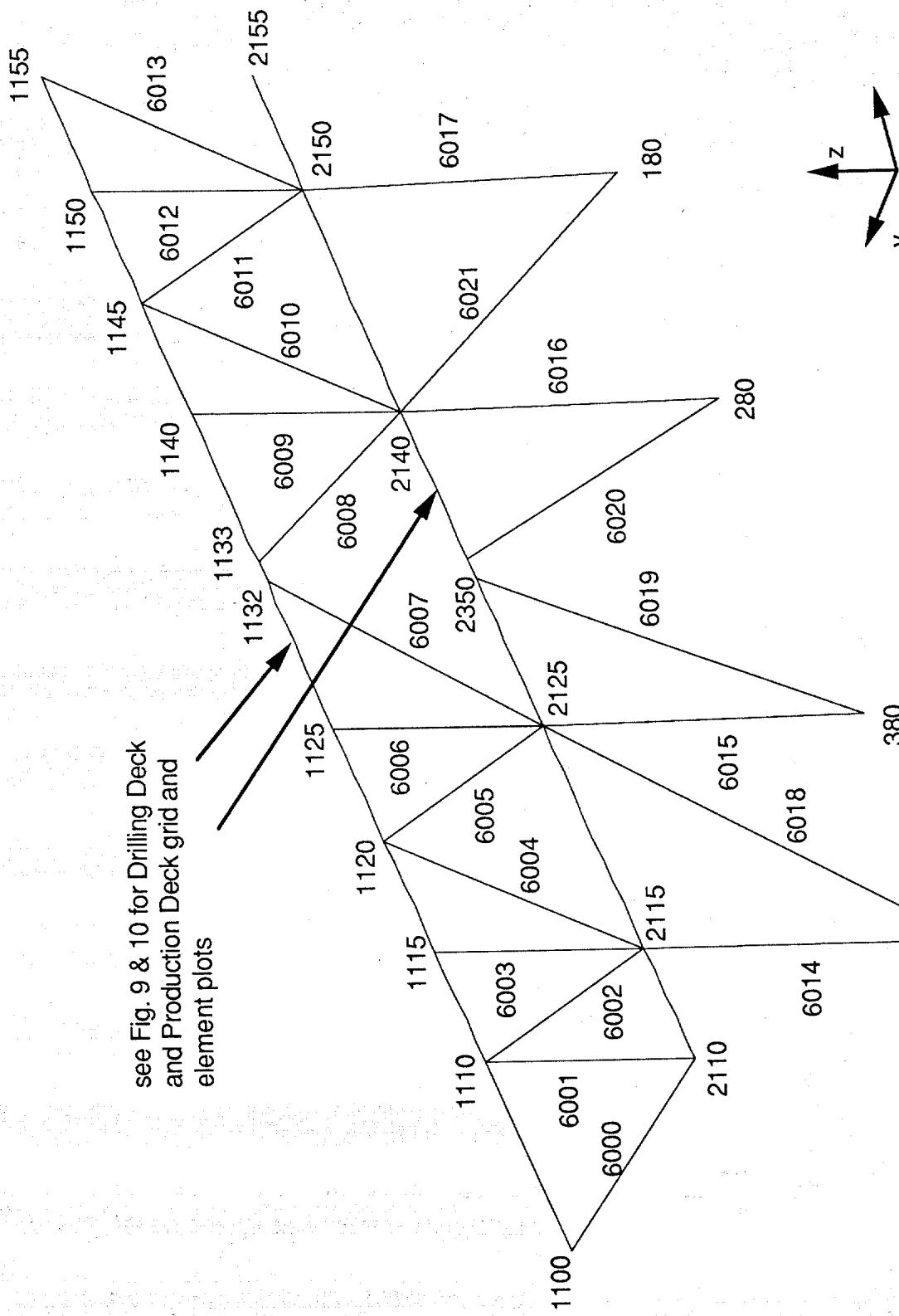
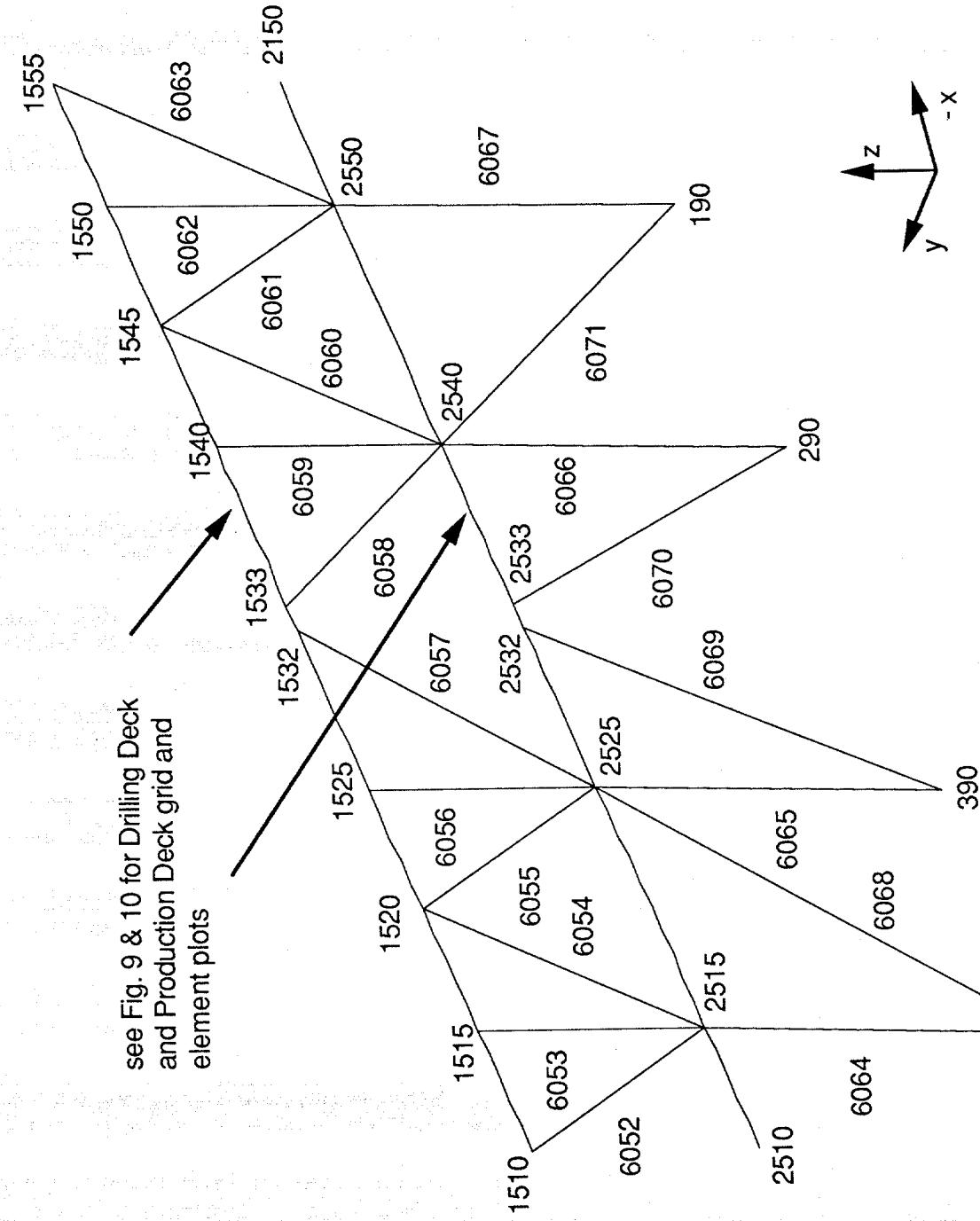


Figure 12 - Row B Elevation Element and Grid Point Numbers

See Fig. 9 & 10 for Drilling Deck  
and Production Deck grid and  
element plots



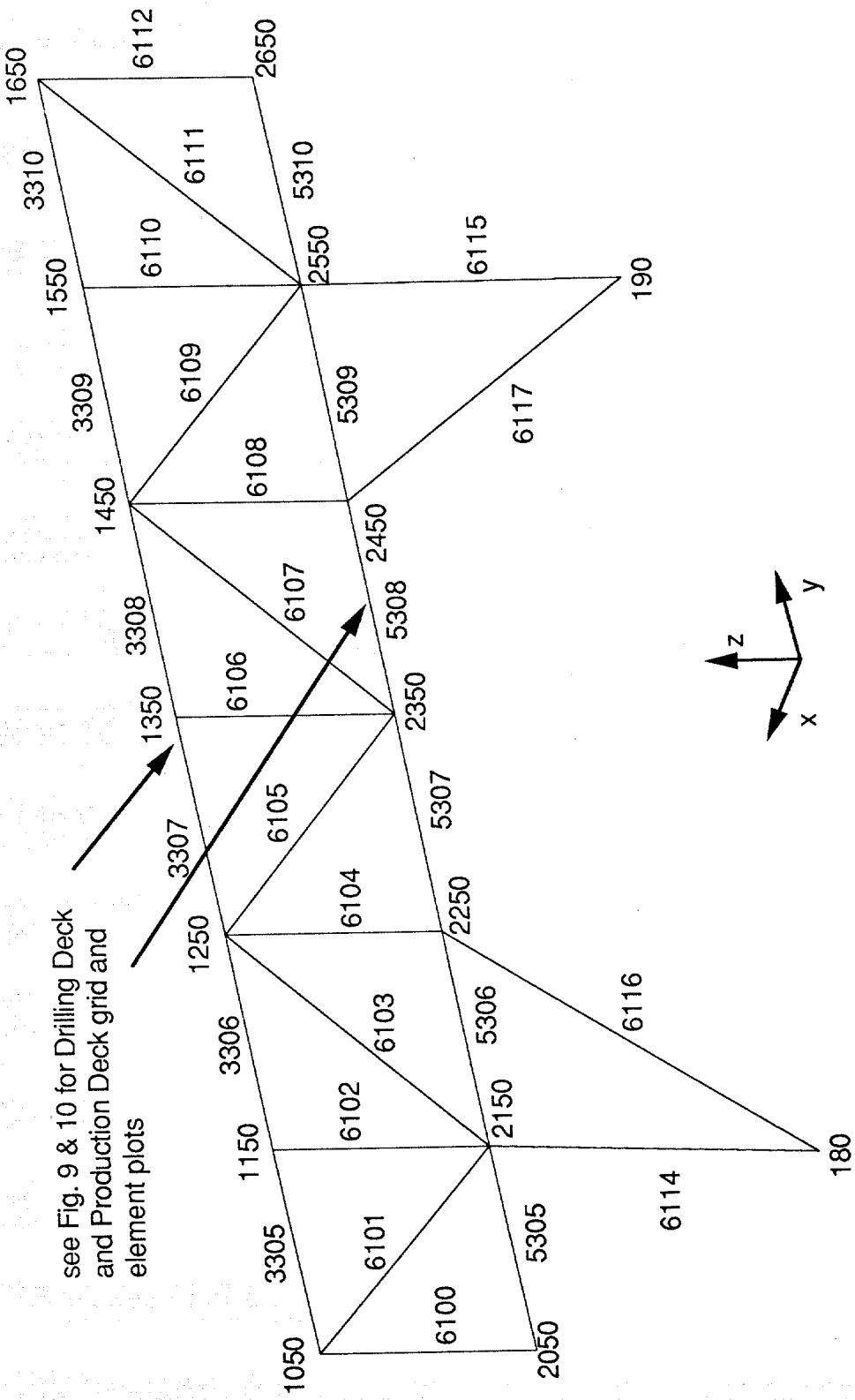


Figure 13 - Row 1 Elevation Element and Grid Point Numbers

see Fig. 9 & 10 for Drilling Deck  
and Production Deck grid and  
element plots

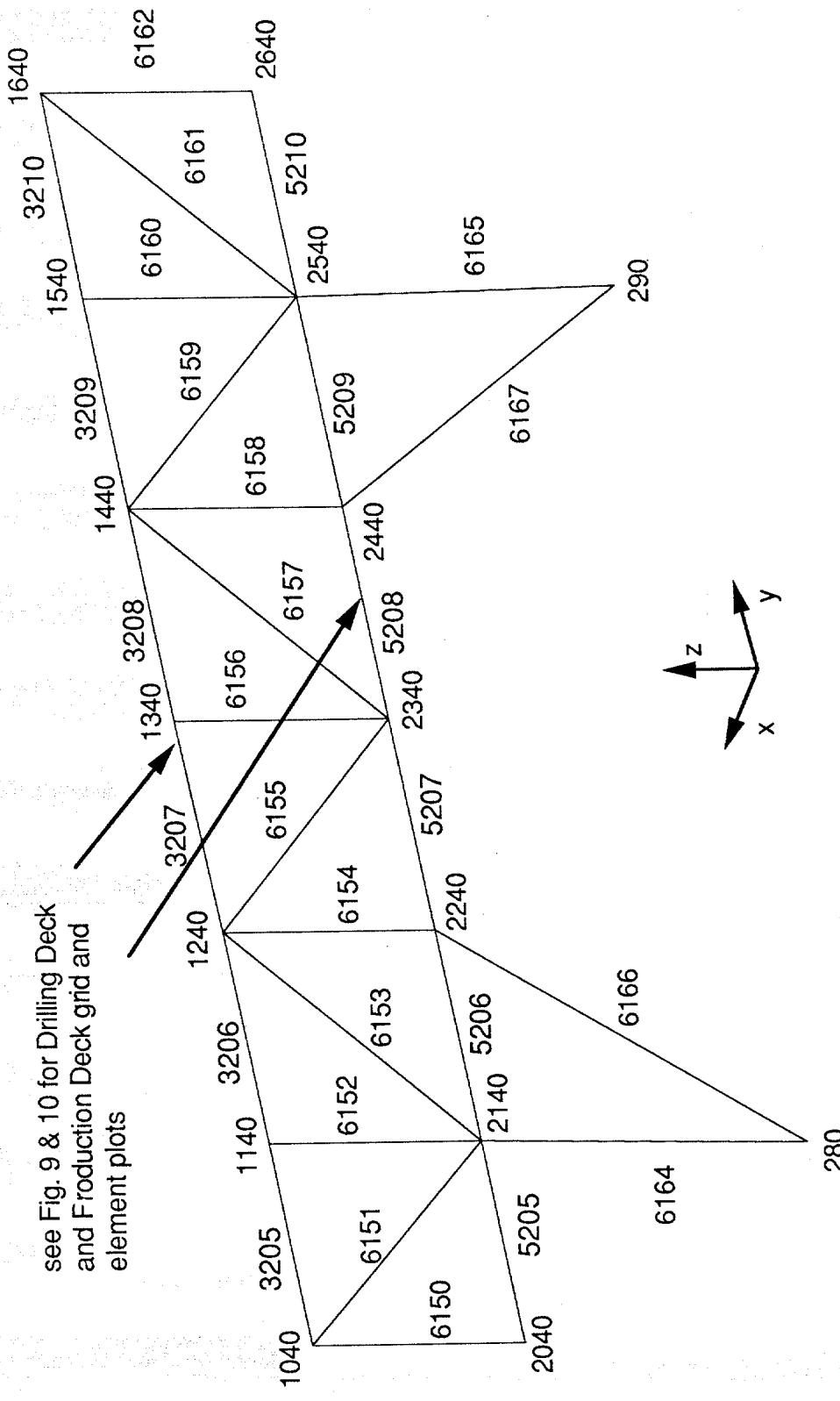


Figure 14 - Row 2 Elevation Element and Grid Point Numbers

see Fig. 9 & 10 for Drilling Deck  
and Production Deck grid and  
element plots

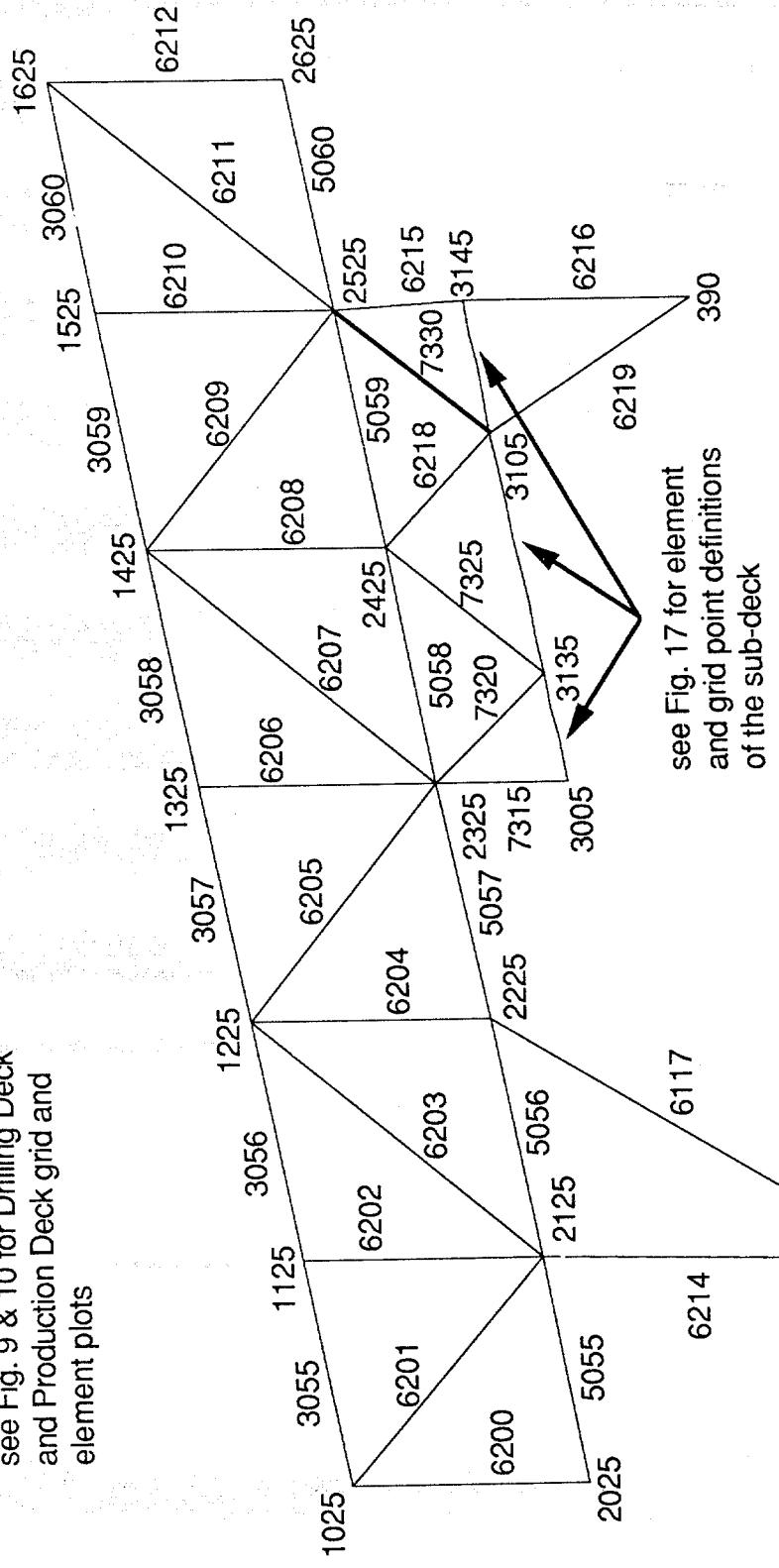


Figure 15 - Row 3 Elevation Element and Grid Point Numbers

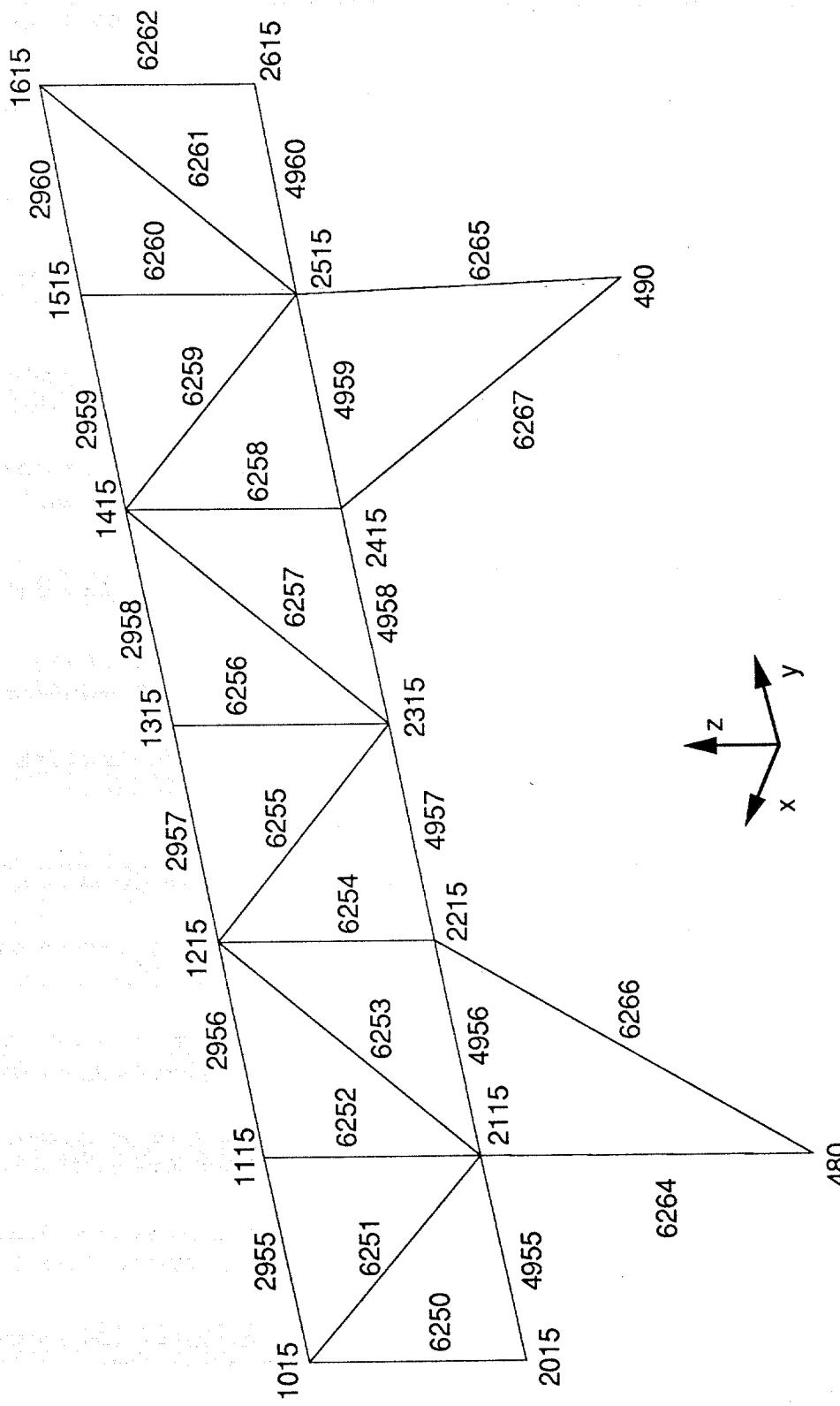


Figure 16 - Row 4 Elevation Element and Grid Point Numbers

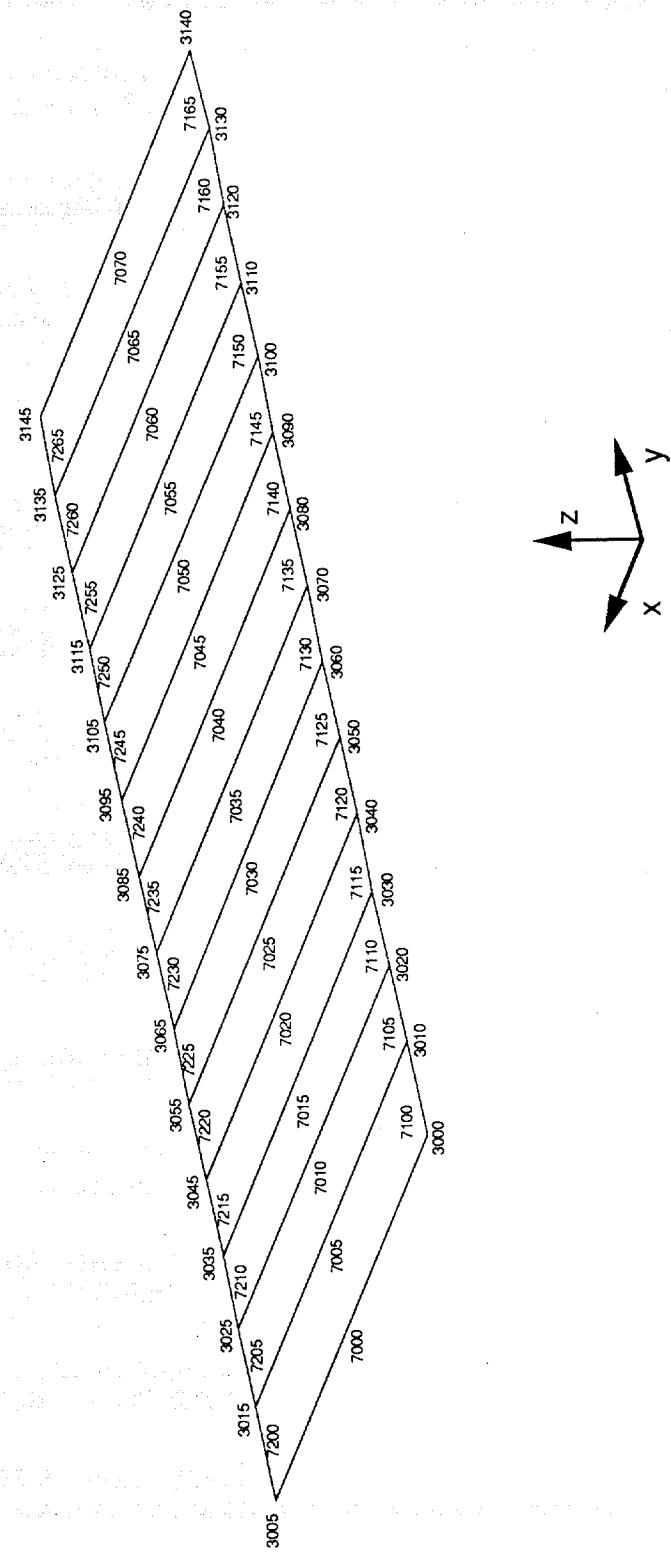
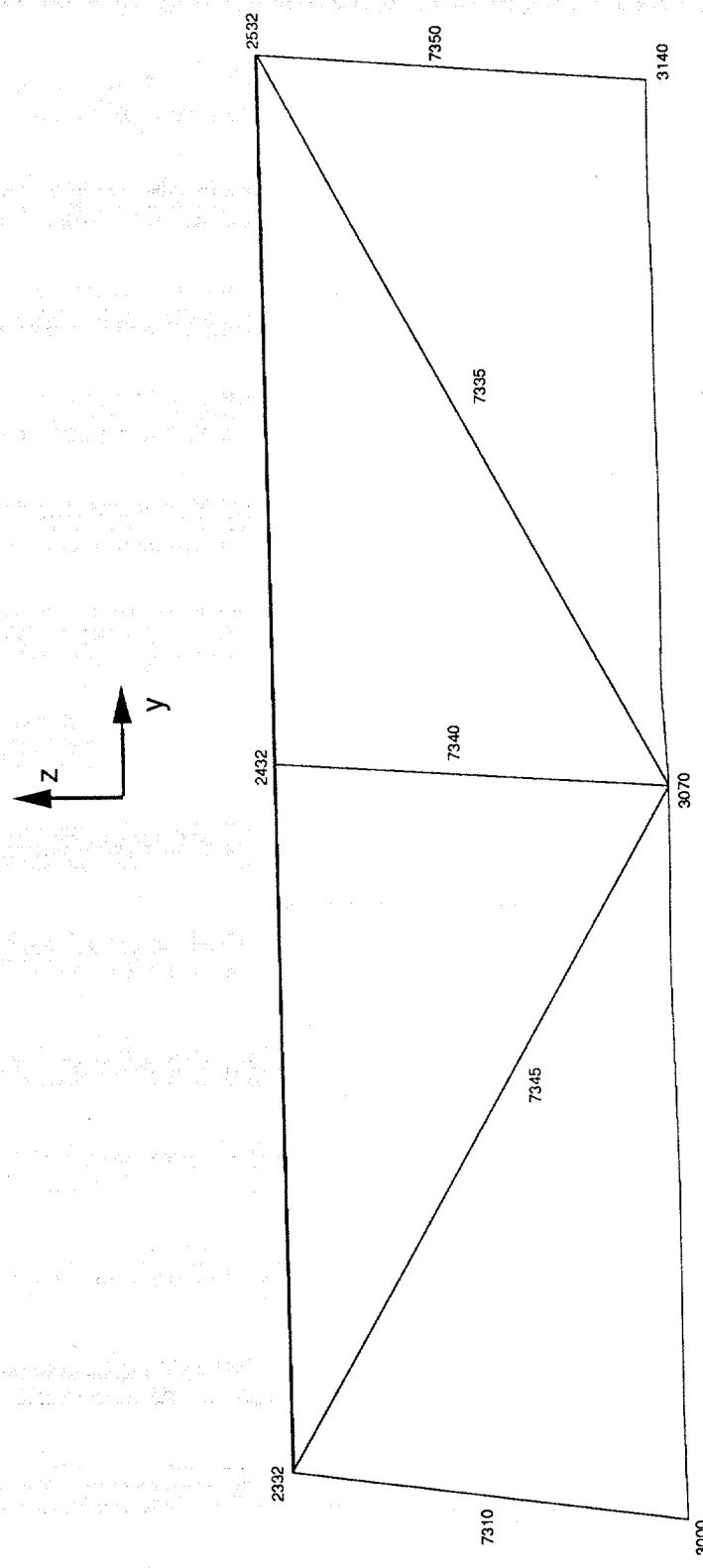


Figure 17 - Sub-Deck Element and Grid Point Numbers

Figure 18 - Sub - Deck Connections to Production Deck (View A) Element and Grid Point Numbers



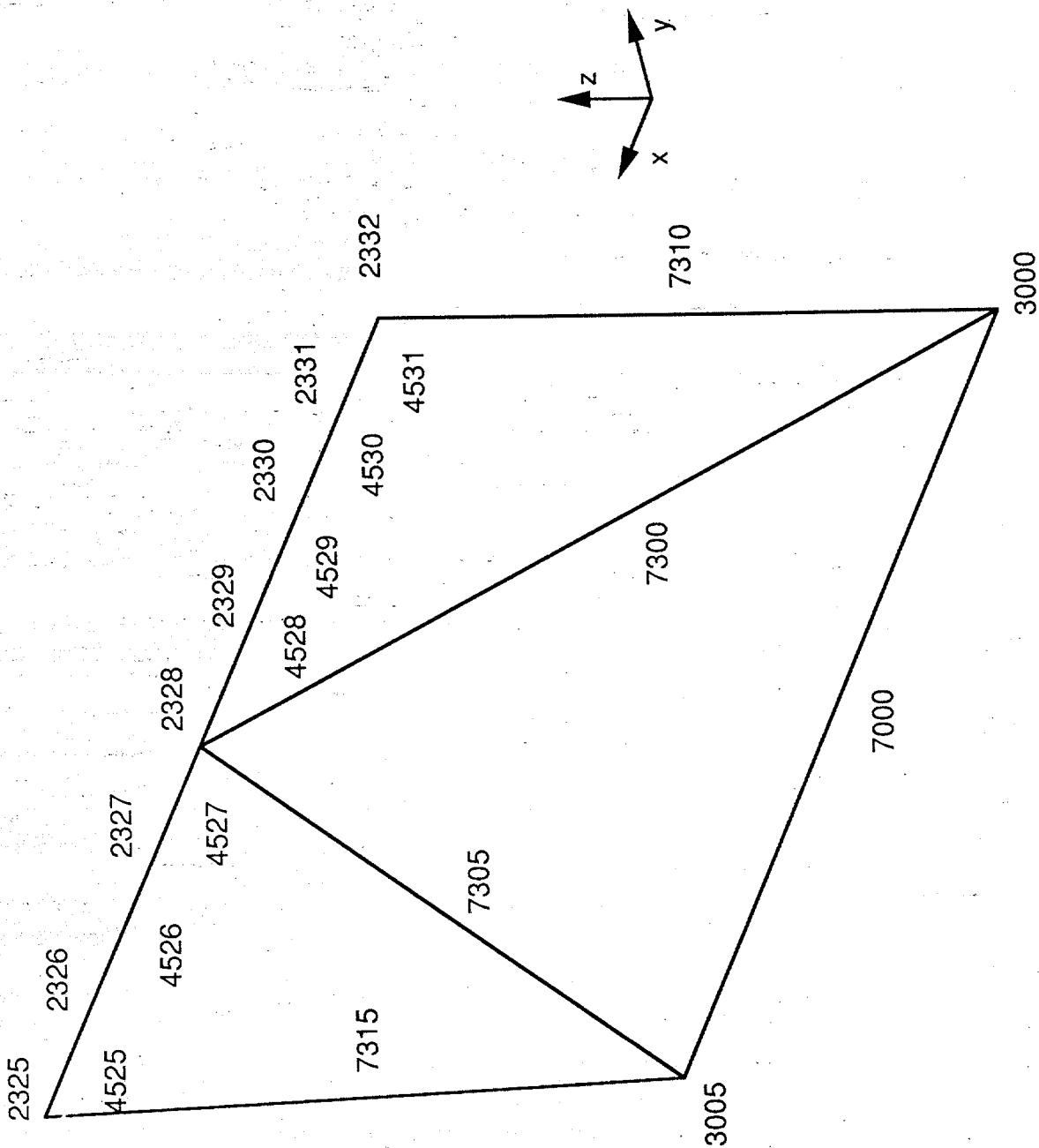


Figure 19 - Sub - Deck Connections to Production Deck (View D) Element and Grid Point Numbers

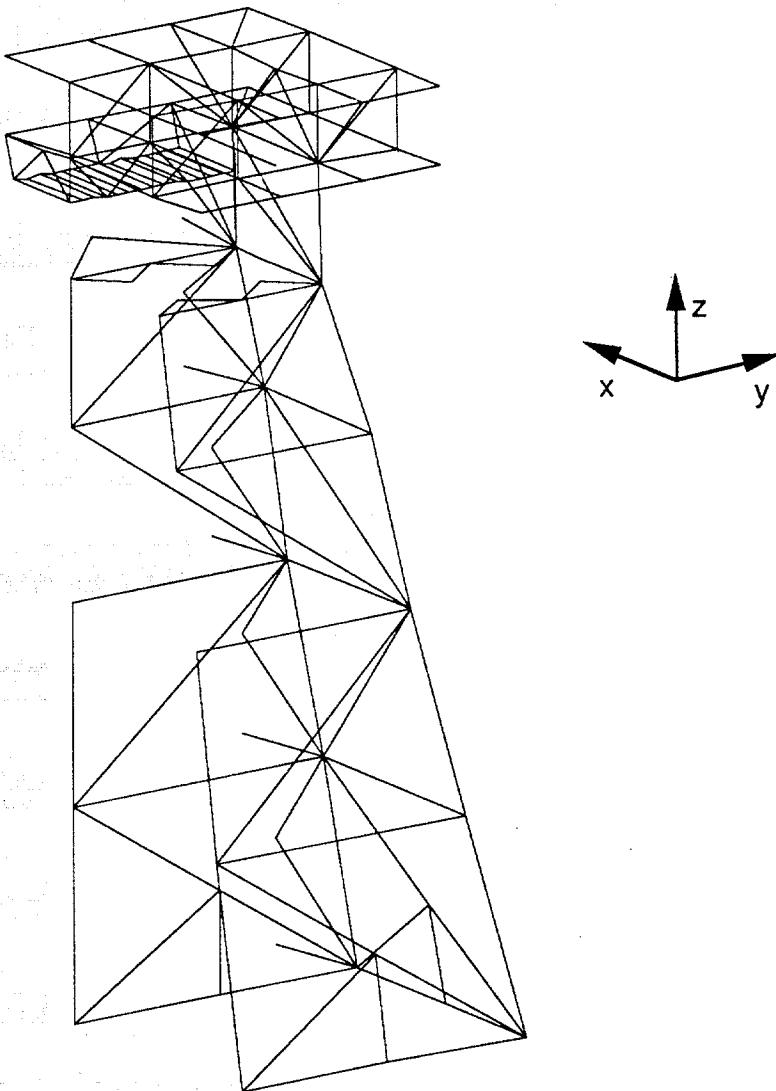


Figure 20 - Symmetric Finite Element Model of Platform IRENE

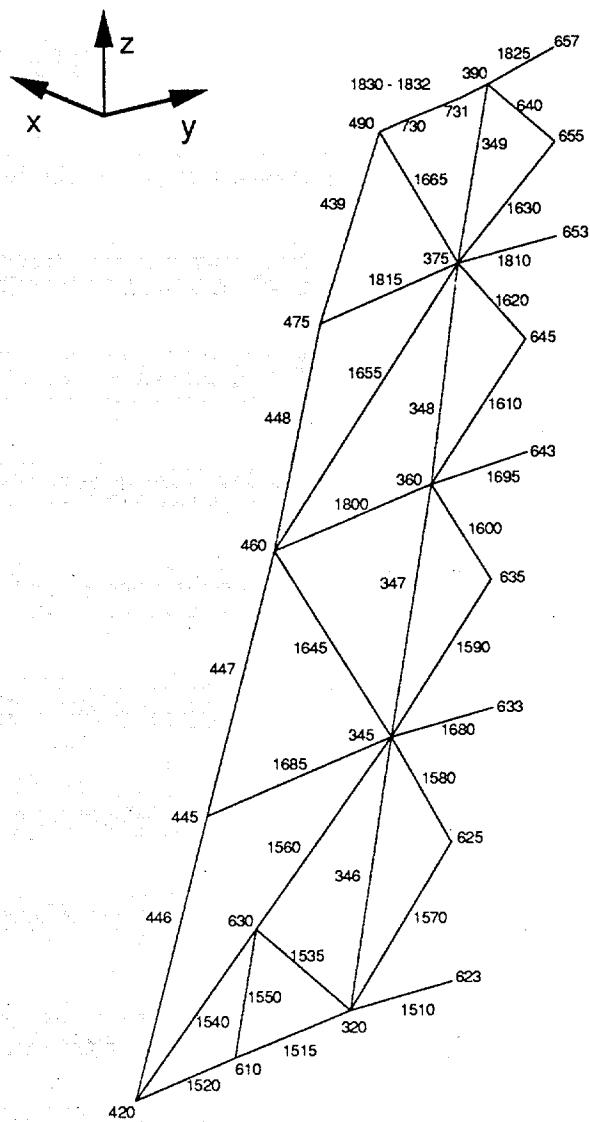


Figure 21 - Jacket Row B Element and Grid Point Numbers of Symmetric Model

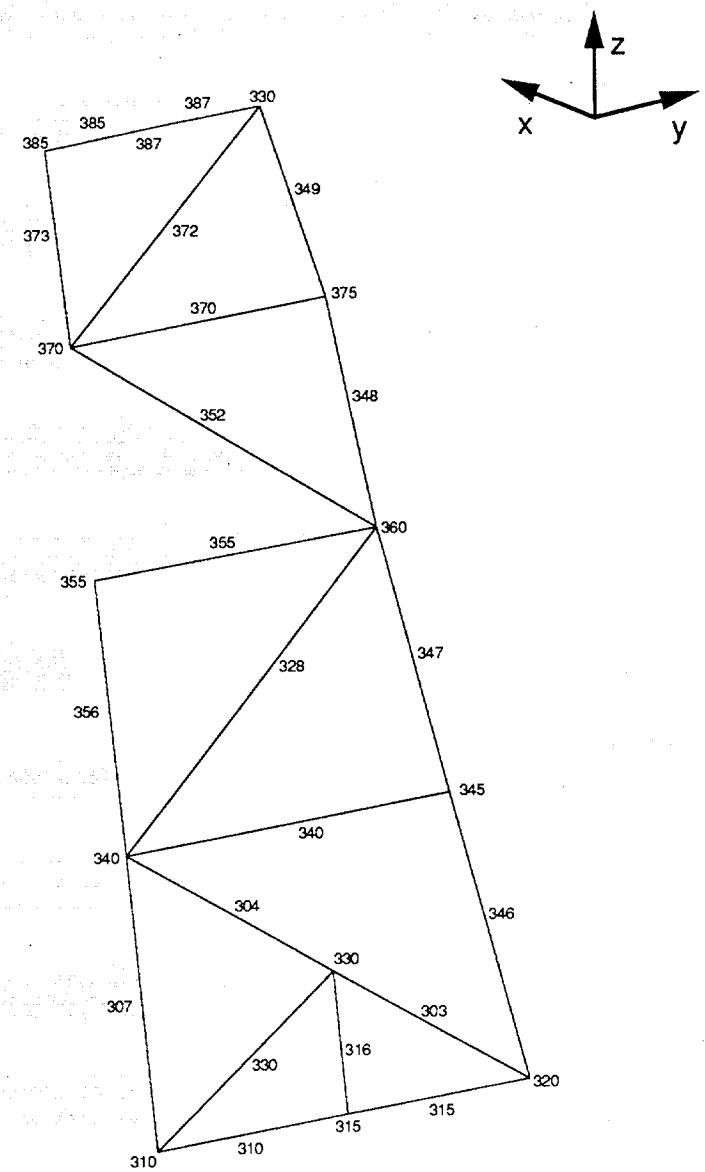


Figure 22 - Jacket Row 3 Element and Grid Point Numbers of Symmetric Model

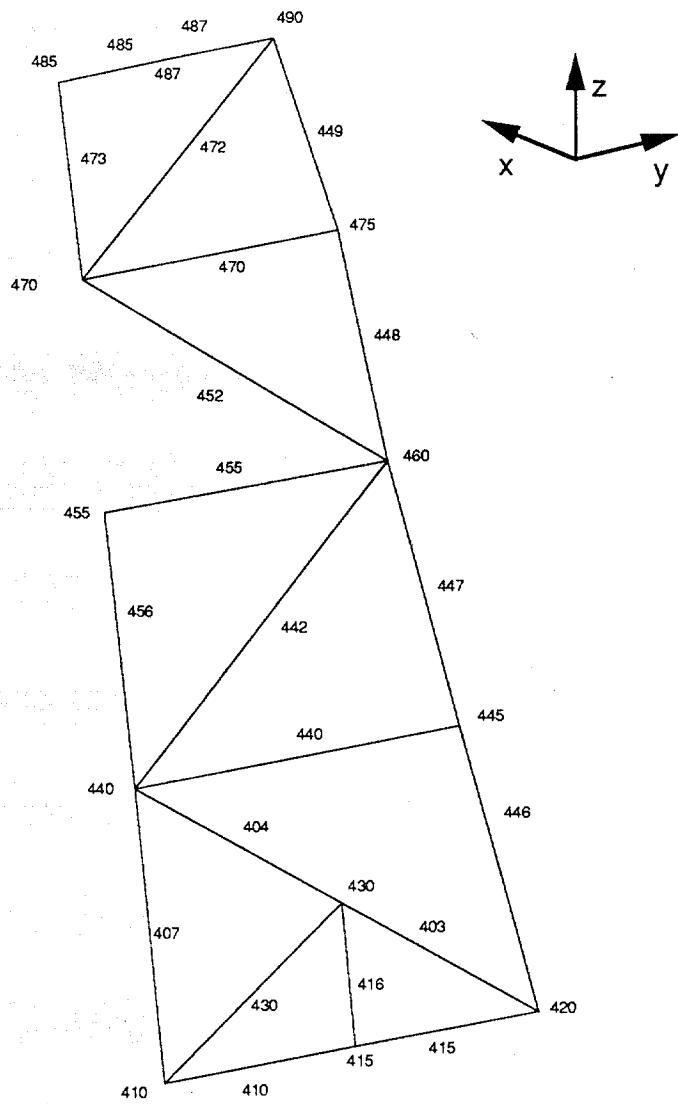
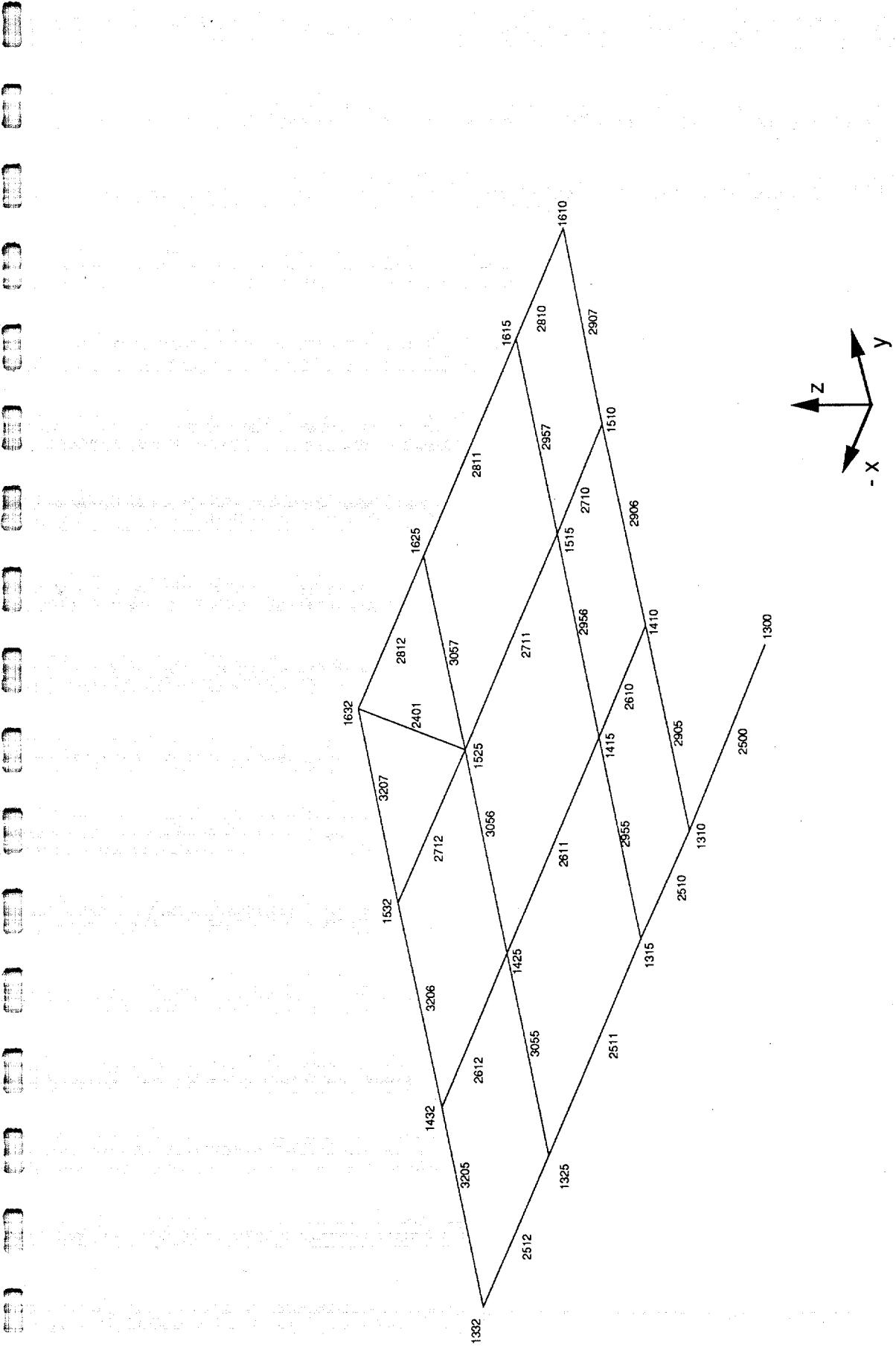
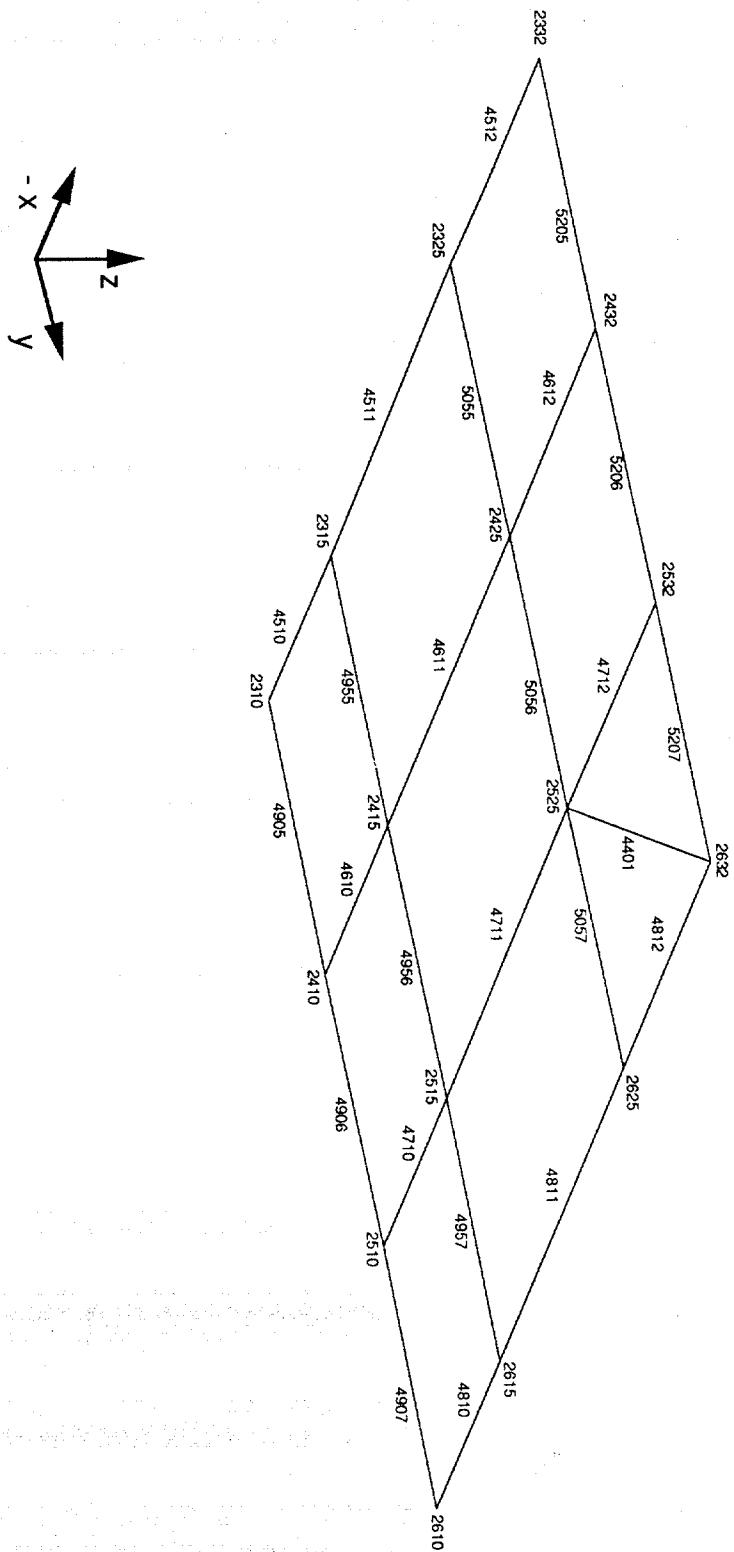


Figure 23 - Jacket Row 4 Element and Grid Point Numbers of Symmetric Model



**Figure 25 - Drilling Deck Element and Grid Point Numbers of Symmetric Model**

Figure 26 - Production Deck Element and Grid Point Numbers of Symmetric Model



see Fig. 25 & 26 for Drilling  
Deck and Production Deck grid  
and element numbers

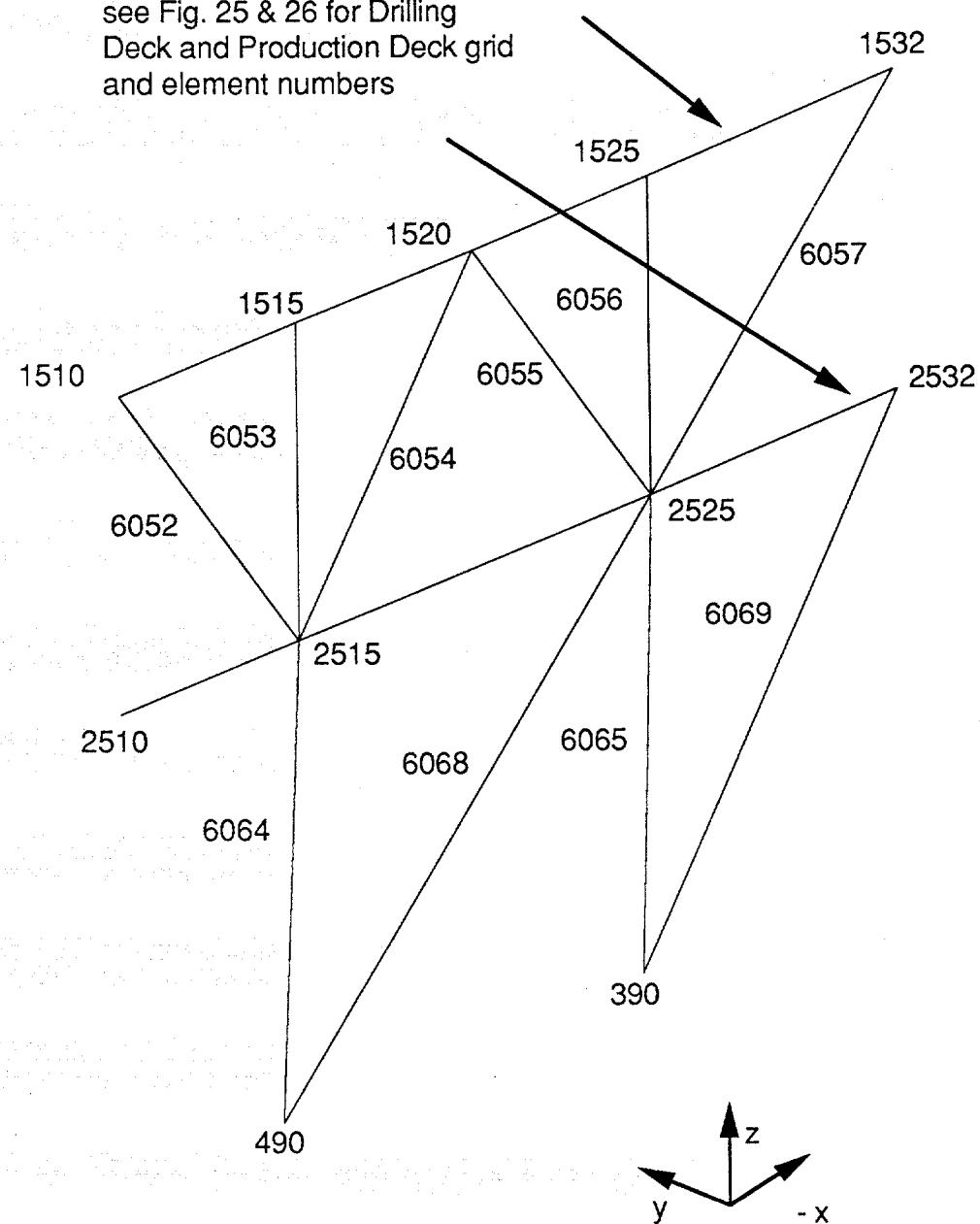
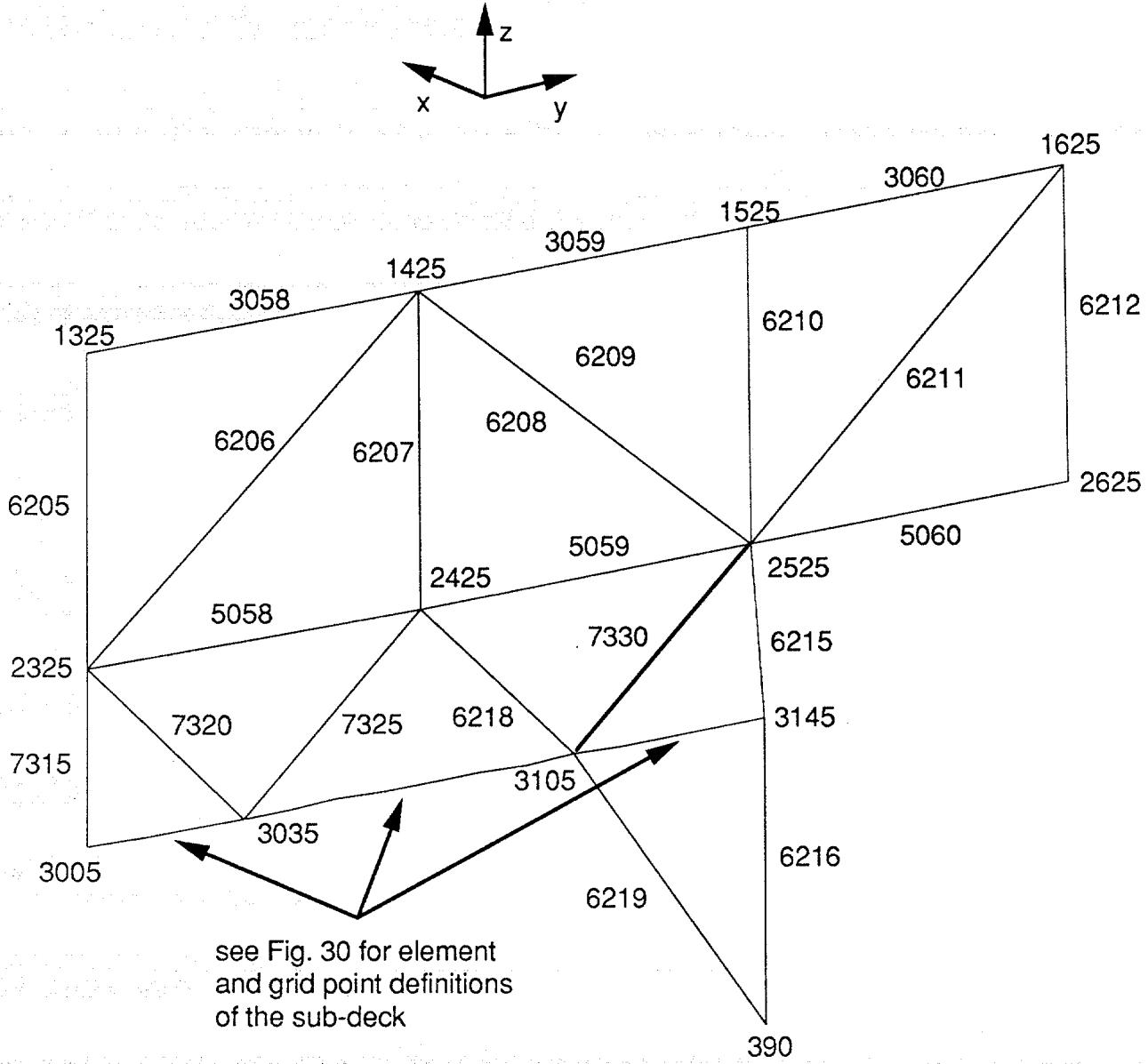


Figure 27 - Row B Elevation Element and Grid Point Numbers of Symmetric Model



**Figure 28 - Row 3 Elevation Element and Grid Point Numbers of Symmetric Model**

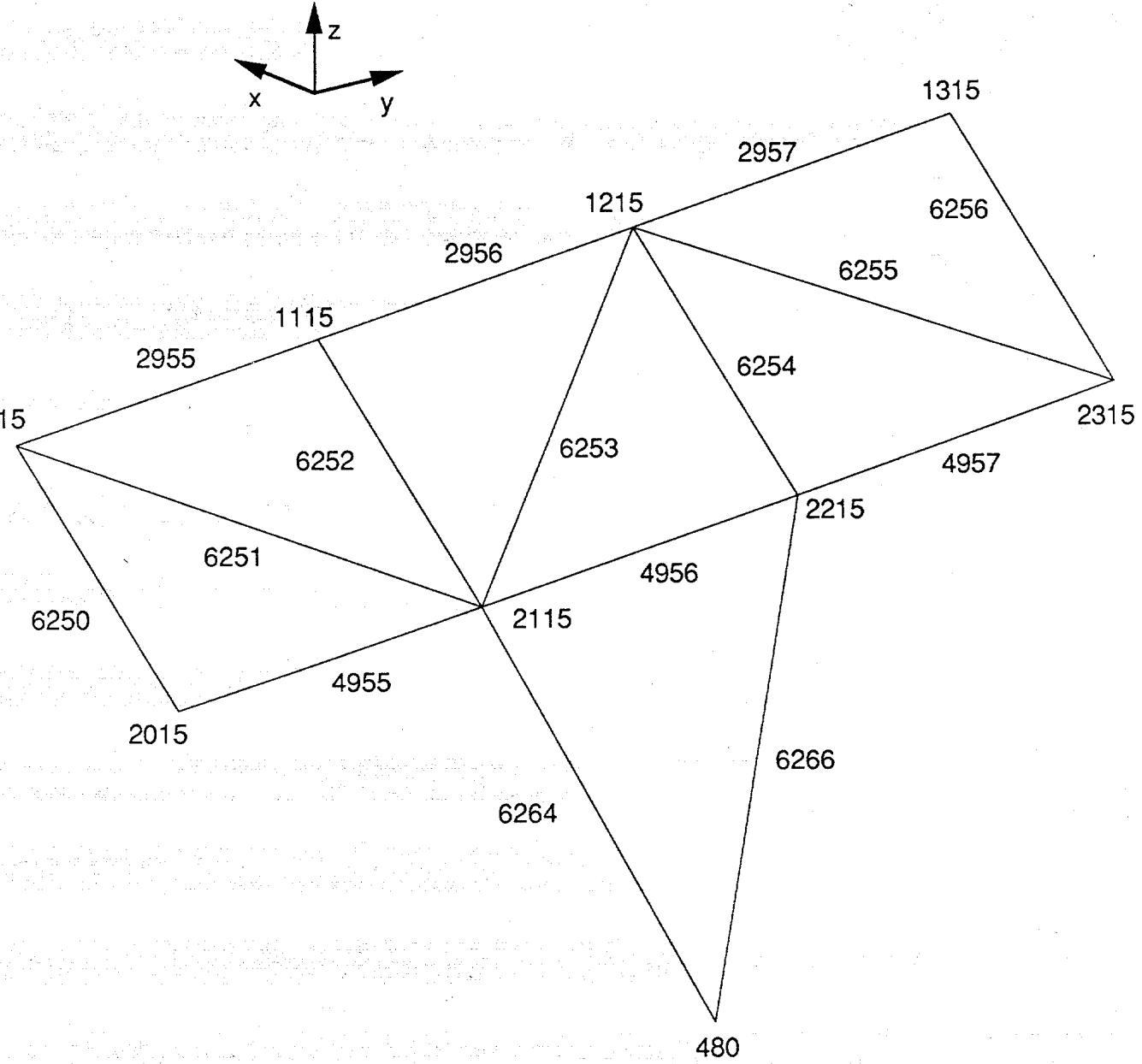


Figure 29 - Row 4 Elevation Element and Grid Point Numbers of Symmetric Model

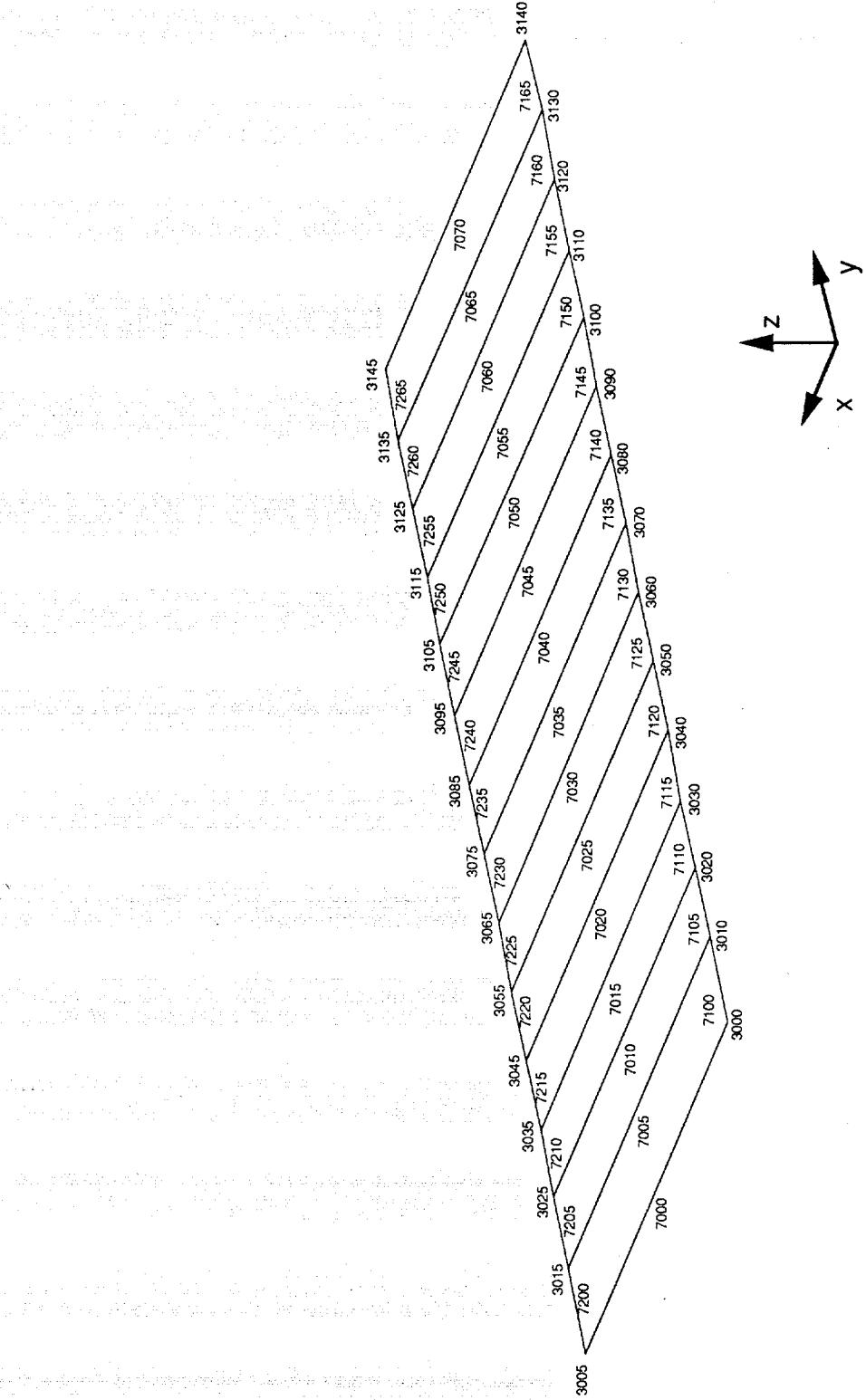


Figure 30 - Sub - Deck Element and Grid Point Numbers of Symmetric Model

Figure 31 - Sub - Deck Connections to Production Deck (View A) Element and Grid Point Numbers of Symmetric Model

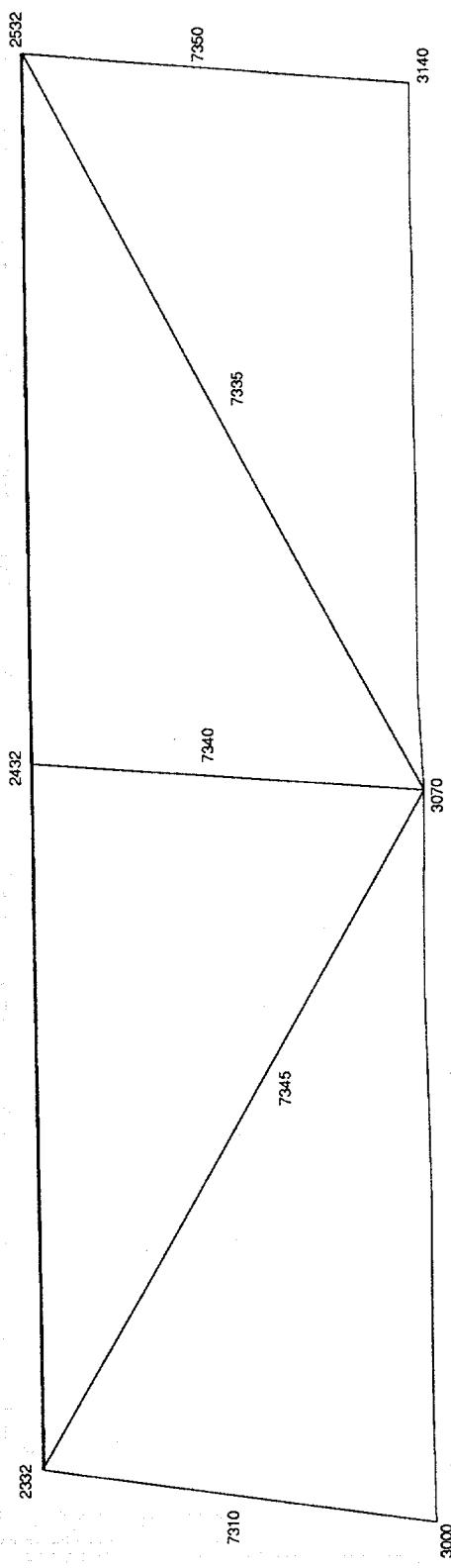
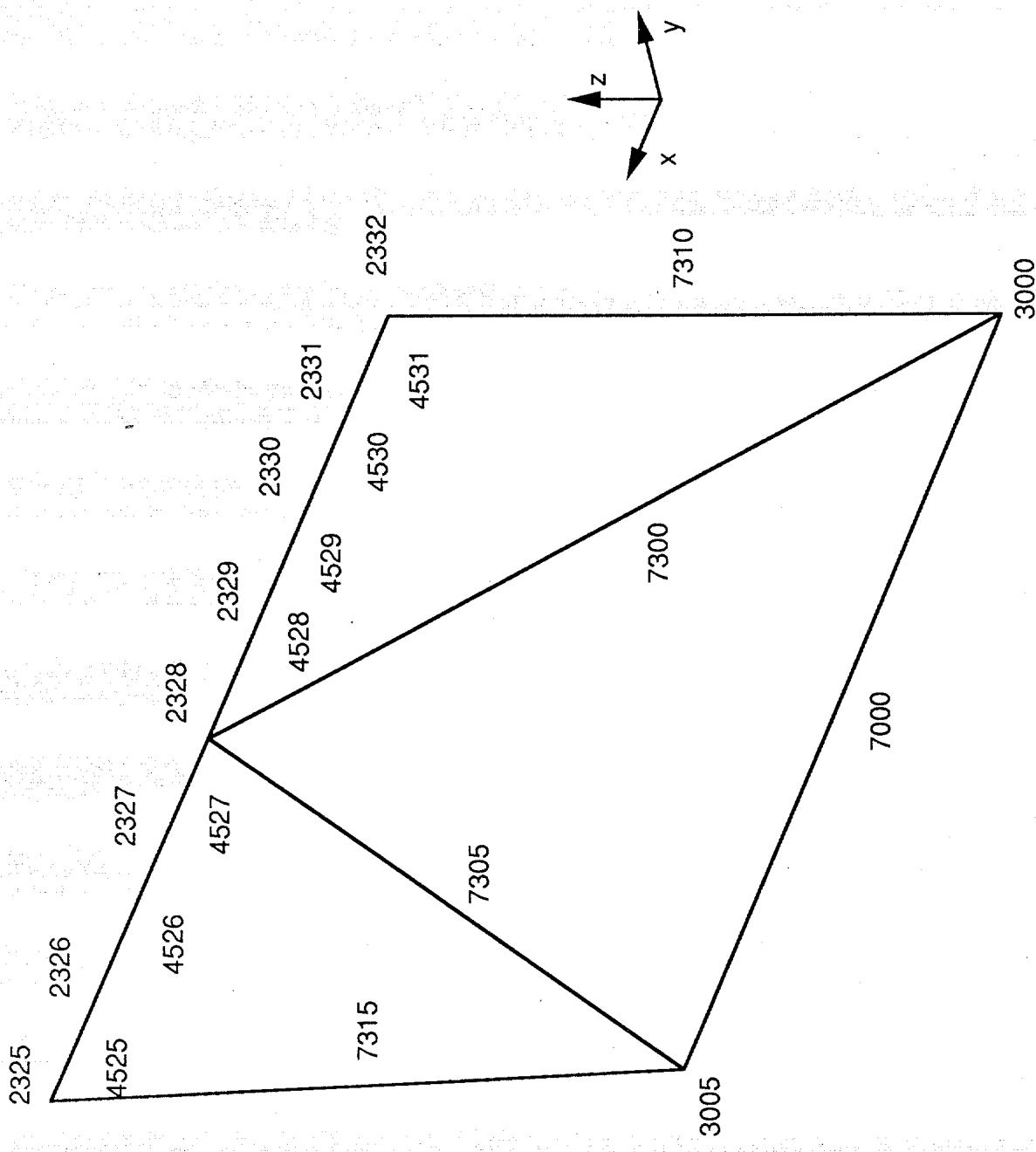


Figure 32 - Sub - Deck Connections to Production Deck (View D) Element and Grid Point Numbers of Symmetric Model



**Table 1 - Jacket Element Property Definitions**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 1 Elements	Row 2 Elements		Row 3 Elements		Row 4 Elements		Row A Elements		Row B Elements	
							Elements	Elements								
64" x 1.0"	64	1	197.92	98218.	138	138	438									
						139	439									
						148	448									
						149	449									
63.5" x 0.75"	63.5	0.75	147.85	72782.	234	234	334									
						236	336									
						237	337									
						233	333									
						238	338									
						232	332									
						239	339									
						246	346									
						247	347									
						248	348									
						249	349									
63.25" x 0.625"	63.25	0.625	122.96	60288.	136	136	436									
						137	437									
						146	446									
						147	447									
54" x 1.0"	54	1	166.50	58485.	203	203	303									
						204	304									
36" x 1.5"	36	1.5	162.58	24234.	265	265	365									
						270	370									

Table 1 - Jacket Element Property Definitions Cont'd

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 1		Row 2		Row 3		Row 4		Row A		Row B	
						Elements											
36" x 1.25"	36	1.25	136.46	20625.	201	201	301	202	302								
36" x 1.0"	36	1	109.96	16851.	101	101	235	102	240	335	340	401	402	403	404	404	
36" x 0.75"	36	0.75	83.06	12906.	135	135	231	140	241	331	229	435	241	329	440	341	440
34" x 1.25"	34	1.25	128.61	17268.	231	231	231		241	331	229	525	241	329	540	341	555
34" x 1.0"	34	1	103.67	14125.	525												560
32" x 1.0"	32	1	97.39	11711.	228					228	328						1525
30" x 1.0"	30	1	91.11	9589.	141	141	142		151	300	305	441	142	210	310	451	1540
									152	205	215	257					1555
										215	215	250					1560
												252					1645
												255					1650

**Table 1 - Jacket Element Property Definitions Cont'd**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 1 Elements	Row 2 Elements	Row 3 Elements	Row 4 Elements	Row A Elements		Row B Elements	
										Elements	Elements	Elements	Elements
30" x 0.75"	30	0.75	68.92	7375.	100	100	254	354	400	500	1500		
						105			405	505	1505		
						110			410	515	1515		
						115			415	520	1520		
						165			465				
						170			470				
26" x 0.75"	26	0.75	59.49	4746.	171	171			471	565	1565		
						172			472	570	1570		
										575	1575		
										580	1580		
										655	1655		
										660	1660		
										665	1665		
										670	1670		
24" x 0.75"	24	0.75	54.78	3705.	271				271	371	1585		
									272	372	1590		
											1595		
											600	1600	
											605	1605	
											610	1610	
											615	1615	
											620	1620	
											825	1825	
24" x 0.625"	24	0.625	45.90	3137.	625						625	1625	
											630	1630	
											635	1635	
											640	1640	

**Table 1 - Jacket Element Property Definitions Cont'd**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 1		Row 2		Row 3		Row 4		Row A Elements		Row B Elements	
						Elements	Elements	Elements	Elements								
24" x 0.5"	24	0.5	36.91	2549.	208			208		308							
22" x 0.5"	22	0.5	33.77	1952.	209			209		309							
20" x 0.625"	20	0.625	38.04	1787.	180	180		273		373	480						
								182			482						
								185			485						
								173			473						
								187			487						
20" x 0.5"	20	0.5	30.63	1457.	150	150		253		353	450					1805	
								155		361	455					1815	
									280			820				1820	
									282			830				1830	
									285			830				1821	
									287			832				1822	
																1831	
																1832	
18" x 0.5"	18	0.5	27.49	1053.	156	156		256		356	456					510	1510
18" x 0.375"	18	0.375	20.76	807.	107	107		207		307	407					675	1675
																685	1685
16" x 0.5"	16	0.5	24.35	732.	690											690	1690
																800	1800
16" x 0.375"	16	0.375	18.41	562.	695											695	1695
																810	1810

Table 1 - Jacket Element Property Definitions Cont'd

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 1		Row 2		Row 3		Row 4		Row A		Row B	
						Elements											
14" x 0.375"	14	0.375	16.05	373.	106	106	206	306	406	530	1530	1535	1535	1545	1550	1680	1680
						116	216	316	416	535							
						126	226	326	426	545							
						130	230	330	430	550							
										680							

Table 2 - Elevation (+) 15' Element Property Definitions

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	El (+) 15' Elements
20" x 0.5"	20	0.5	30.63	1457.	2030	2030-2032 2035-2037
18" x 0.5"	18	0.5	27.49	1053.	2015	2015 2016 2020-2027
14" x 0.375"	14	0.375	16.05	373.	2040	2040-2045 2050-2055 2060-2065 2070-2075

**Table 3 - Drilling Deck Element Property Definitions**

Spec	Area	Moment of Inertia	Moment of Inertia	Property Number	Drilling Deck
W36 x 182	53.54	11281.5	327.7	2210	2210 - 2224
					2810 - 2824
					2840 - 2854
W36 x 194	57	12100	375	2310	2310 - 2354
					2710 - 2754
					2400 - 2401
					2300
W36 x 230	67.73	14988.4	870.9	2225	2225 - 2254
					2410 - 2424
					2510 - 2524
					2610 - 2624
					2640 - 2654
					2825 - 2839
W36 x 260	76.56	17233.8	1120.6	2425	2425 - 2454
					2625 - 2639
W36 x 300	88.17	20290.2	1225.2	2525	2525 - 2554
W21 x 57	16.7	1170	30.6	2915	2905 - 2910
					2915 - 2920
					2925 - 2930
					2935 - 2940
					2945 - 2950
					2965 - 2970
					2975 - 2980
					2985 - 2990
					2995 - 3000
					3005 - 3010
W21 x 75	23.4	2340	61.2	3015	3015 - 3020
					3025 - 3030
					3035 - 3040
					3045 - 3050
					3065 - 3070
					3075 - 3080
					3085 - 3090
					3095 - 3100
					3105 - 3110

**Table 3 - Drilling Deck Element Property Definitions Cont'd**

Spec	Area	Moment of Inertia	Moment of Inertia	Property Number	Drilling Deck
W21 x 57	16.7	1170	30.6	2915	3115 - 3120 3125 - 3130 3135 - 3140 3145 - 3150 3155 - 3160 3165 - 3170 3175 - 3180 3185 - 3190 3195 - 3200 3215 - 3220 3225 - 3230 3235 - 3240 3245 - 3250 3255 - 3260 3265 - 3270 3275 - 3280 3285 - 3290 3295 - 3300 3315 - 3320 3325 - 3330 3335 - 3340 3345 - 3350
W36 X 194	57	12100	375	2955	2955 - 2960 3055 - 3060 3205 - 3210 3305 - 3310 3355 - 3360
16" x 0.5"	24.35	732	732	2305	2305 - 2308

**Table 4 - Production Deck Element Property Definitions**

Spec	Area	Moment of Inertia	Moment of Inertia	Property Number	Production Deck
W36 x 194	57.11	12103.4	355.4	4225	4225 - 4239 4825 - 4839
W36 x 182	53.54	11281.5	327.7	2210	4415 - 4424 4440 - 4449 4615 - 4624 4640 - 4649
W36 x 160	47.09	9738.8	275.4	4400	4400 - 4401
W36 x 135	39.7	7800	225	4210	4210 - 4224 4240 - 4254 4810 - 4824 4840 - 4854
W36 x 160	47.09	9738.8	275.4	4310	4310 - 4354 4710 - 4754
W36 x 230	67.73	14988.4	870.9	2225	4410 - 4414 4450 - 4454 4510 - 4524 4540 - 4554 4610 - 4614 4625 - 4639 4650 - 4654
W36 x 260	76.56	17233.8	1120.6	2425	4425 - 4439
W36 x 300	88.17	20290.2	1225.2	2525	4525 - 4539
W14 x 34	10	339.2	21.3	4915	4915 - 4920 4925 - 4930 4935 - 4940 4945 - 4950 4965 - 4970 4975 - 4980 4985 - 4990 4995 - 5000 5005 - 5010 5015 - 5020 5025 - 5030 5035 - 5040

**Table 4 - Production Deck Element Property Definitions Cont'd**

Spec	Area	Moment of Inertia	Moment of Inertia	Property Number	Production Deck
W14 x 34	10	339.2	21.3	4915	5045 - 5050 5065 - 5070 5075 - 5080 5085 - 5090 5095 - 5100 5105 - 5110 5115 - 5120 5125 - 5130 5135 - 5140 5145 - 5150 5155 - 5160 5165 - 5170 5175 - 5180 5185 - 5190 5195 - 5200 5215 - 5220 5225 - 5230 5235 - 5240 5245 - 5250 5255 - 5260 5265 - 5270 5275 - 5280 5285 - 5290 5295 - 5300 5315 - 5320 5325 - 5330 5335 - 5340 5345 - 5350
W36 x 160	47.09	9738.8	275.4	4955	4905 - 4910 4955 - 4960 5055 - 5060 5205 - 5210 5305 - 5310 5355 - 5360

Table 5 - Elevation Element Property Definitions

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Elevation Row 1	Elevation Row 2	Elevation Row 3	Elevation Row 4	Elevation Row A	Elevation Row B
48" x 1.0"	48	0.75	111.33	31077.	6003	6102	6152	6202	6252	6003	6053
						6110	6160	6210	6260	6006	6056
						6114	6164	6214	6264	6009	6059
						6115	6165	6215	6265	6012	6062
								6216		6014	6064
									6015	6065	
									6016	6066	
									6017	6067	
30" x 1.25"	30	1.25	112.90	11687.	6106	6106					
30" x 1.0"	30	1	91.11	9589.	6156			6156	6206	6256	
28" x 1.25"	28	1.25	105.05	9417.	6104	6104					
28" x 1.0"	28	1	84.82	7740.	6103	6103					
28" x 0.875"	28	0.875	74.56	6865.	6153						
									6153	6204	6253
									6154	6208	6254
									6158	6258	6258
									6159	6259	6259

Table 5 - Elevation Element Property Definitions Cont'd

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Elevation Row 1	Elevation Row 2	Elevation Row 3	Elevation Row 4	Elevation Row A	Elevation Row B
28" x 0.75"	28	0.75	64.21	5964.	6155	6155	6203	6255			
					6157	6205	6257				
					6207						
					6209						
26" x 0.875"	26	0.875	69.07	5456.	6018	6116	6217	6266	6018	6068	
					6117	6167	6218	6267	6021	6071	
					6219						
24" x 0.875"	24	0.875	63.57	4255.	6101	6101	6201	6251			
					6111	6161	6211	6261			
24" x 0.75"	24	0.75	54.78	3705.	6007						
18" x 0.625"	18	0.625	34.12	1289.	6002						
18" x 0.5"	18	0.5	27.49	1053.	6000						
18" x 0.438"	18	0.438	24.17	932.	6100	6100	6150	6200	6162	6250	
					6112					6212	6262

**Table 6 - Sub Deck Element Property Definitions**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Moment of Inertia	Property Number	Sub-Deck
16" x 0.625"	16	0.625	30.19	894.	894.	7100	7100 - 7165 7200 - 7265
16" x 0.5"	16	0.5	24.35	732.	732.	7000	7000 7070
10.75" x 0.594"	10.75	0.594	18.95	245.	245.	7310	7310 - 7315 7350
10.75" x 0.5"	10.75	0.5	16.10	212.	212.	7300	7300 - 7305 7320 - 7345
12" x 8" x 0.5"			18.4	353.	188.	7005	7005 - 7065

**Table 7 - Jacket Element Property Definitions for Symmetric Model**

	Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 3 Elements	Row 4 Elements	Row B Elements
	64" x 1.0"	64	1	197.92	98218.	138			448 - 449
	63.5" x 0.75"	63.5	0.75	147.85	72782.	234			346
									347
									348
									349
	63.25" x 0.625"	63.25	0.625	122.96	60288.	136			446 - 448
	54" x 1.0"	54	1	166.50	58485.	203			303
									304
	36" x 1.5"	36	1.5	162.58	24234.	265			370
	36" x 1.0"	36	1	109.96	16851.	101			403
									404
	36" x 0.75"	36	0.75	83.06	12906.	135			440
	34" x 1.0"	34	1	103.67	14125.	525			1540
									1560
	32" x 1.0"	32	1	97.39	11711.	228			328
	30" x 1.0"	30	1	91.11	9589.	141			442
									315
									452
									352
									355
	30" x 0.75"	30	0.75	68.92	7375.	100			410
									415
									1515
									1520
									470
	26" x 0.75"	26	0.75	59.49	4746.	171			472
									1570
									1580
									1655
									1665
	24" x 0.75"	24	0.75	54.78	3705.	271			1590
									1600
									1610
									1620
									1825

**Table 7 - Jacket Element Property Definitions for Symmetric Model Cont'd**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Row 3 Elements	Row 4 Elements	Row B Elements
24" x 0.625"	24	0.625	45.90	3137.	625			1630 1640
20" x 0.625"	20	0.625	38.04	1787.	180	373	485	473 487
20" x 0.5"	20	0.5	30.63	1457.	150		455	1815 1830 1831 1832
18" x 0.5"	18	0.5	27.49	1053.	156	356	456	1510
18" x 0.375"	18	0.375	20.76	807.	107	307	407	1685
16" x 0.5"	16	0.5	24.35	732.	690			1800
16" x 0.375"	16	0.375	18.41	562.	695			1695 1810
14" x 0.375"	14	0.375	16.05	373.	106	316	416	1535
						330	430	1550 1680

**Table 8 - Elevation (+) 15' Element Property Definitions for Symmetric Model**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	El (+) 15' Elements
18" x 0.5"	18	0.5	27.49	1053.	2015	2025 2026
14" x 0.375"	14	0.375	16.05	373.	2040	2051 2052 2054 2055 2071 2072 2074 2075

**Table 9 - Drilling Deck Element Property Definitions for Symmetric Model**

Spec	Area	Moment of Inertia	Moment of Inertia	Property Number	Drilling Deck
W36 x 182	53.54	11281.5	327.7	2210	2810
					2811
					2812
W36 x 194	57	12100	375	2310	2710
					2711
					2712
					2713
					2401
W36 x 230	67.73	14988.4	870.9	2225	2500
					2510
					2511
					2512
					2610
					2611
W21 x 57	16.7	1170	30.6	2915	2905
					2906
					2907
					2955
W36 X 194	57	12100	375	2955	2956
					2957
					3055
					3056
					3057
					3205
					3206
					3207

Table 11 - Elevation Element Property Definitions for Symmetric Model

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Property Number	Elevation Row 3	Elevation Row 4	Elevation Row B
48" x 1.0"	48	0.75	111.33	31077.	6003	6210 6215 6216	6260 6265	6053 6056 6064 6065
30" x 1.0"	30	1	91.11	9589.	6156	6206	6256	
28" x 0.875"	28	0.875	74.56	6865.	6153	6208	6258 6259	
28" x 0.75"	28	0.75	64.21	5964.	6155	6207	6257	
26" x 0.875"	26	0.875	69.07	5456.	6018	6218 6219	6267	6068
24" x 0.875"	24	0.875	63.57	4255.	6101	6211	6261	
24" x 0.75"	24	0.75	54.78	3705.	6007			6057 6069
18" x 0.5"	18	0.5	27.49	1053.	6000			6052 6054 6055
18" x 0.438"	18	0.438	24.17	932.	6100	6212		6262

**Table 12 - Sub Deck Element Property Definitions for Symmetric Model**

Spec	Diameter	Wall Thickness	Area	Moment of Inertia	Moment of Inertia	Property Number	Sub-Deck
16" x 0.625"	16	0.625	30.19	894.	894.	7100	7100 - 7165 7200 - 7265
16" x 0.5"	16	0.5	24.35	732.	732.	7000	7000 7070
10.75" x 0.594"	10.75	0.594	18.95	245.	245.	7310	7310 - 7315 7350
10.75" x 0.5"	10.75	0.5	16.10	212.	212.	7300	7300 - 7305 7320 - 7345
12" x 8" x 0.5"			18.4	353.	188.	7005	7005 - 7065

Table 13 - Predicted Eigenvalues for Platform IRENE Symmetric Model

Mode Number	Eigenvalue	Frequency rad/sec	Frequency hz	Generalized Mass	Generalized Stiffness
1	60.82	7.80	1.24	1	61
2	116.39	10.79	1.72	1	116
3	121.71	11.03	1.76	1	122
4	131.10	11.45	1.82	1	131
5	137.59	11.73	1.87	1	138
6	140.44	11.85	1.89	1	140
7	202.86	14.24	2.27	1	203
8	211.68	14.55	2.32	1	212
9	247.37	15.73	2.50	1	247
10	341.36	18.48	2.94	1	341
11	376.23	19.40	3.09	1	376
12	450.87	21.23	3.38	1	451
13	482.37	21.96	3.50	1	482
14	570.62	23.89	3.80	1	571
15	700.71	26.47	4.21	1	701
16	732.22	27.06	4.31	1	732
17	849.76	29.15	4.64	1	850
18	860.49	29.33	4.67	1	860
19	866.25	29.43	4.68	1	866
20	890.61	29.84	4.75	1	891
21	971.06	31.16	4.96	1	971
22	1006.50	31.73	5.05	1	1007
23	1255.02	35.43	5.64	1	1255
24	1578.20	39.73	6.32	1	1578
25	1764.76	42.01	6.69	1	1765
26	1794.28	42.36	6.74	1	1794
27	1864.50	43.18	6.87	1	1864
28	1885.65	43.42	6.91	1	1886
29	2135.12	46.21	7.35	1	2135
30	2545.33	50.45	8.03	1	2545
31	2550.09	50.50	8.04	1	2550
32	2629.04	51.27	8.16	1	2629
33	2922.77	54.06	8.60	1	2923
34	2987.43	54.66	8.70	1	2987
35	3112.13	55.79	8.88	1	3112
36	3421.02	58.49	9.31	1	3421
37	3425.84	58.53	9.32	1	3426
38	3460.74	58.83	9.36	1	3461
39	3486.05	59.04	9.40	1	3486
40	4279.08	65.41	10.41	1	4279
41	4306.24	65.62	10.44	1	4306

Table 13 - Predicted Eigenvalues for Platform IRENE Symmetric Model Cont'd

Mode Number	Eigenvalue	Frequency rad/sec	Frequency hz	Generalized Mass	Generalized Stiffness
42	4485.15	66.97	10.66	1	4485
43	4802.15	69.30	11.03	1	4802
44	4926.29	70.19	11.17	1	4926
45	5068.55	71.19	11.33	1	5069
46	5146.42	71.74	11.42	1	5146
47	5519.18	74.29	11.82	1	5519
48	5723.81	75.66	12.04	1	5724
49	5805.62	76.19	12.13	1	5806
50	5888.62	76.74	12.21	1	5889
51	5959.82	77.20	12.29	1	5960
52	6171.04	78.56	12.50	1	6171
53	6322.02	79.51	12.65	1	6322
54	6731.66	82.05	13.06	1	6732
55	7013.93	83.75	13.33	1	7014
56	7493.36	86.56	13.78	1	7493
57	8045.93	89.70	14.28	1	8046
58	8147.54	90.26	14.37	1	8148
59	8838.40	94.01	14.96	1	8838
60	9473.33	97.33	15.49	1	9473
61	11665.12	108.01	17.19	1	11665
62	11917.00	109.17	17.37	1	11917
63	12747.14	112.90	17.97	1	12747
64	13392.37	115.73	18.42	1	13392
65	14023.78	118.42	18.85	1	14024
66	15337.98	123.85	19.71	1	15338
67	15453.67	124.31	19.79	1	15454
68	15761.82	125.55	19.98	1	15762

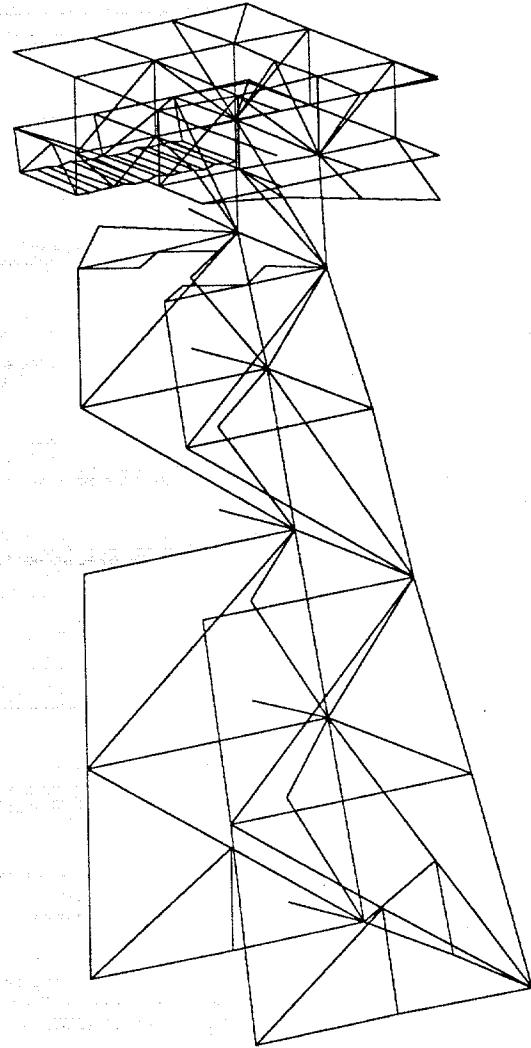


Figure 33 - Platform IRENE Eighth Mode - 2.32 Hz

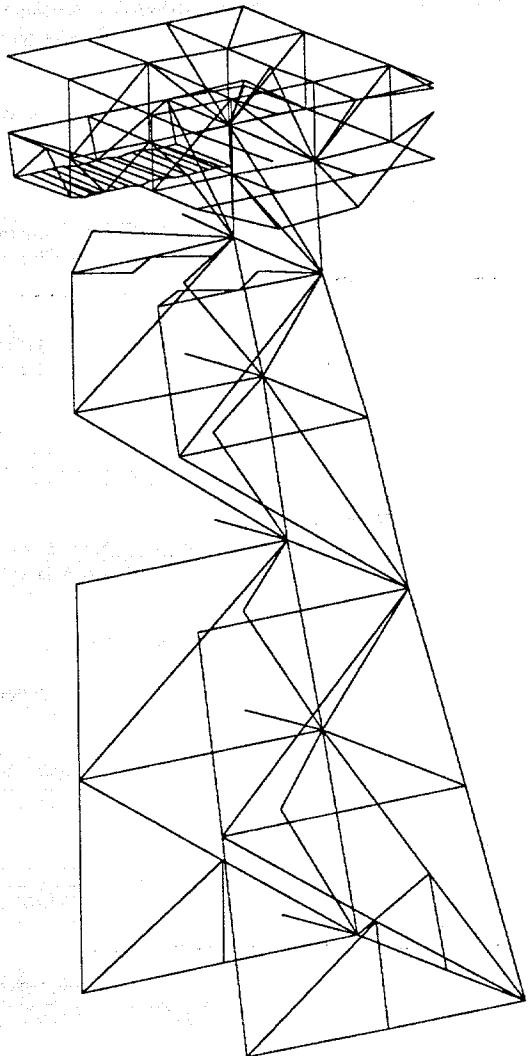


Figure 34 - Platform IRENE Tenth Mode - 2.94 Hz

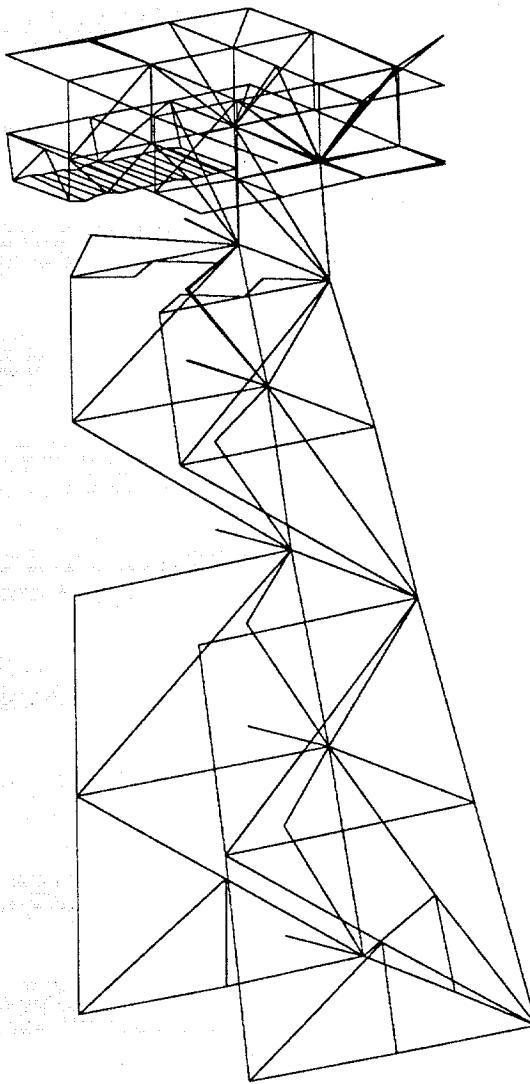


Figure 35 - Platform IRENE Thirteenth Mode - 3.50 Hz

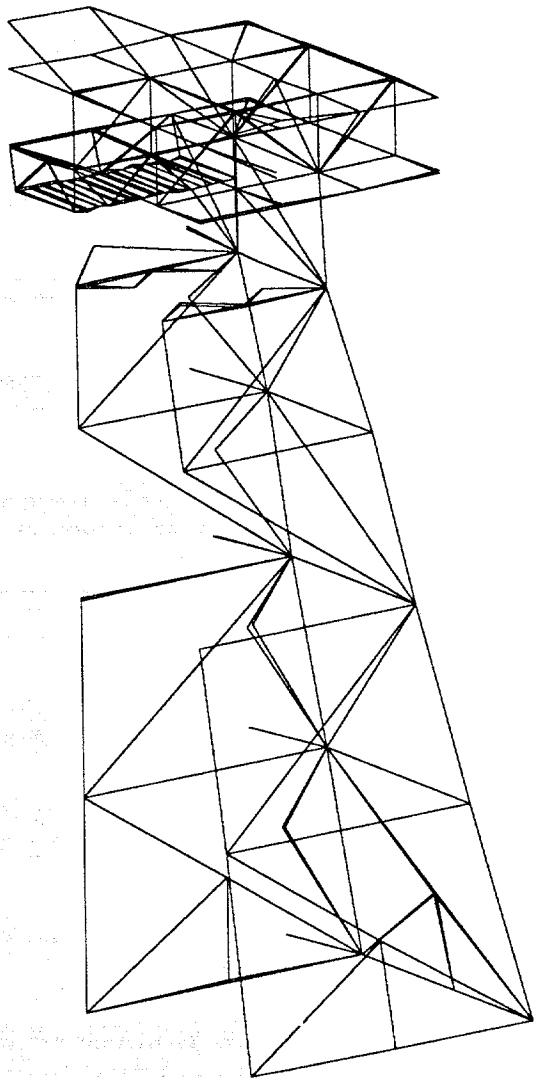


Figure 36 - Platform IRENE Twentieth Mode - 4.75 Hz

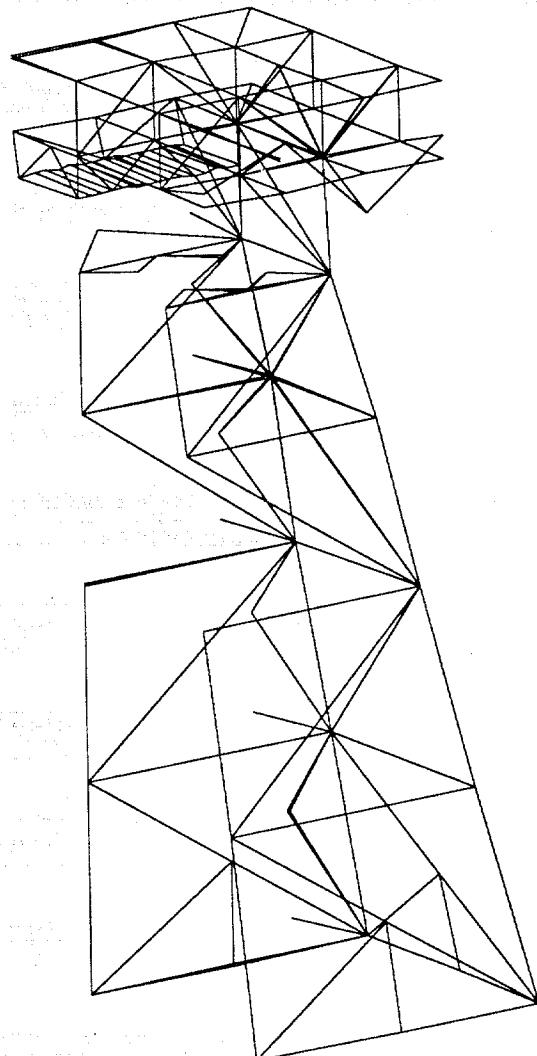


Figure 37 - Platform IRENE Twenty Second Mode - 5.05 Hz

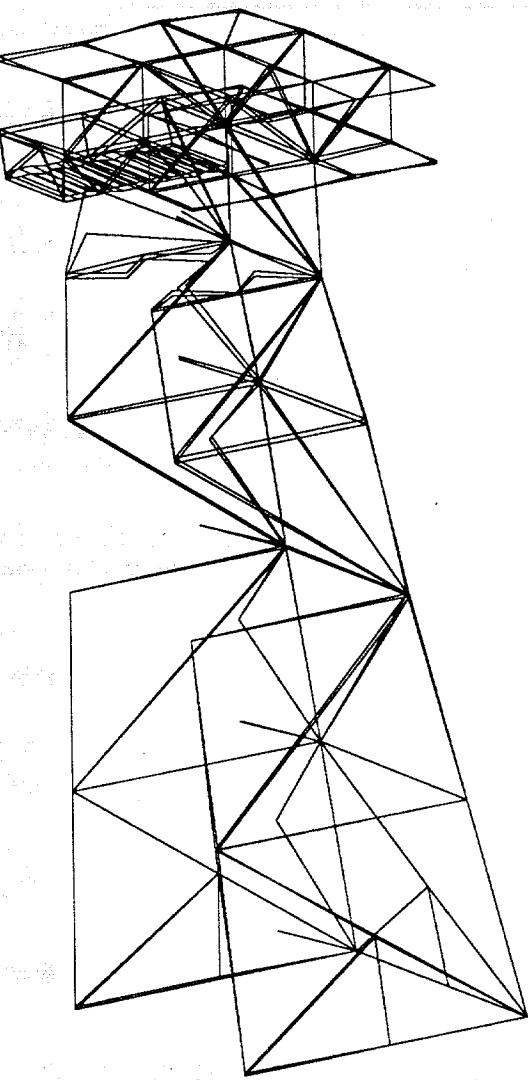


Figure 38 - Platform IRENE Twentyfourth Mode - 6.32 Hz

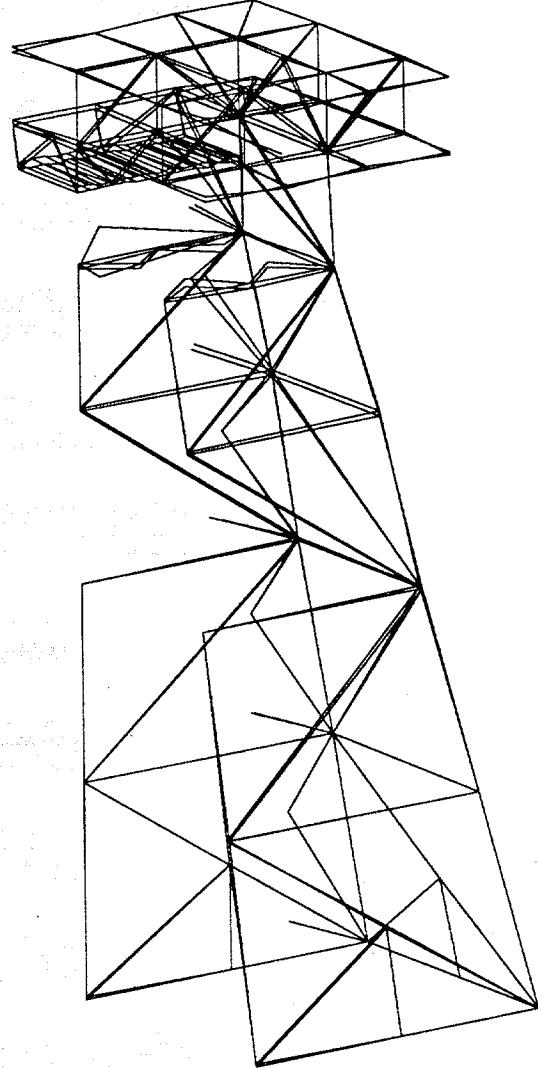


Figure 39 - Platform IRENE Twentyfifth Mode - 6.69 Hz

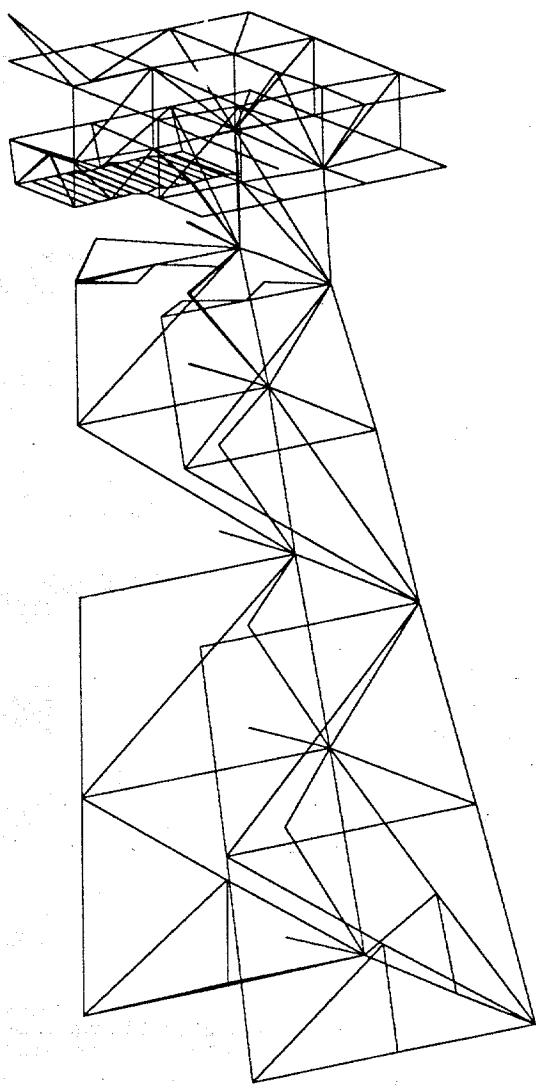


Figure 40 - Platform IRENE Twentysixth Mode - 6.74 Hz

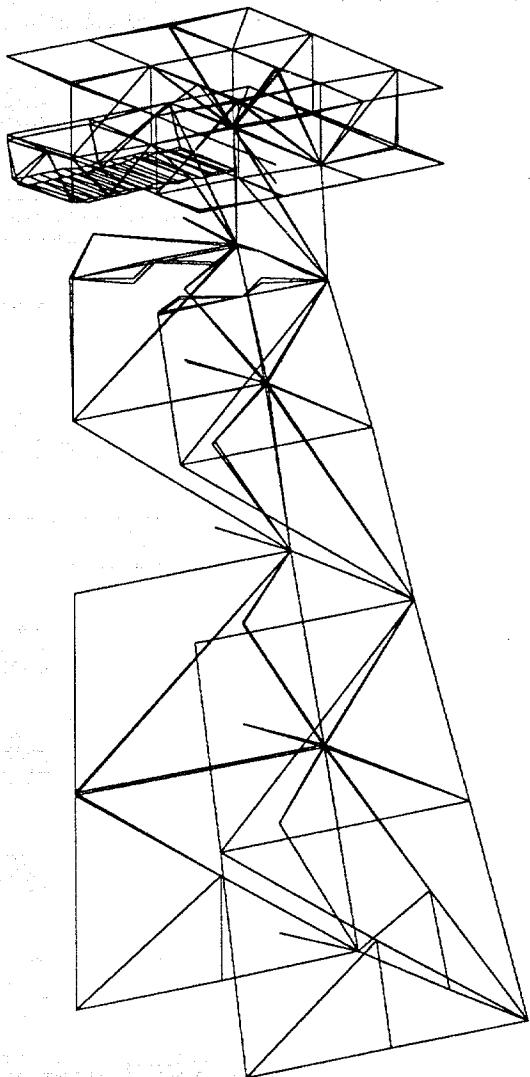


Figure 41 - Platform IRENE Thirtieth Mode - 8.03 Hz

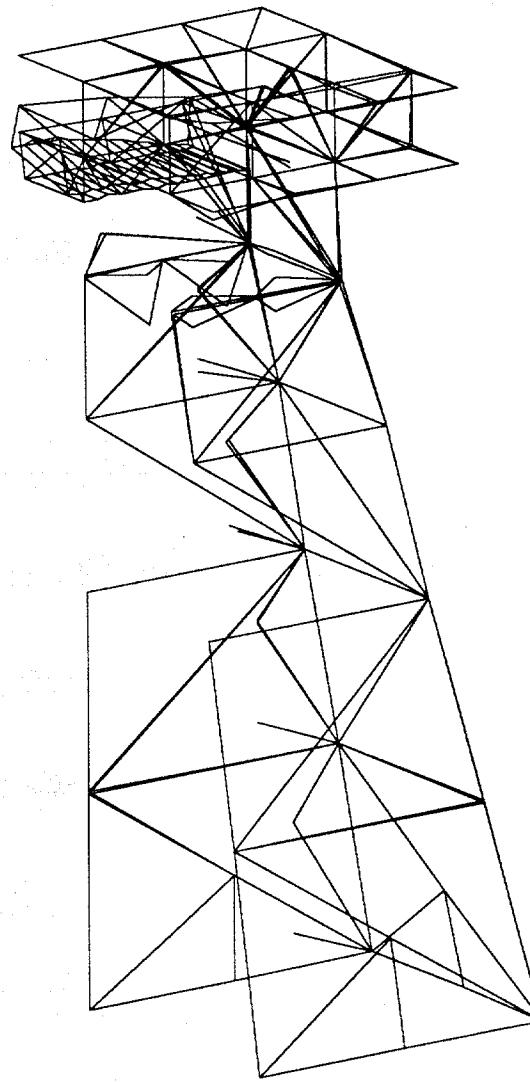


Figure 42 - Platform IRENE Thirtythird Mode - 8.60 Hz

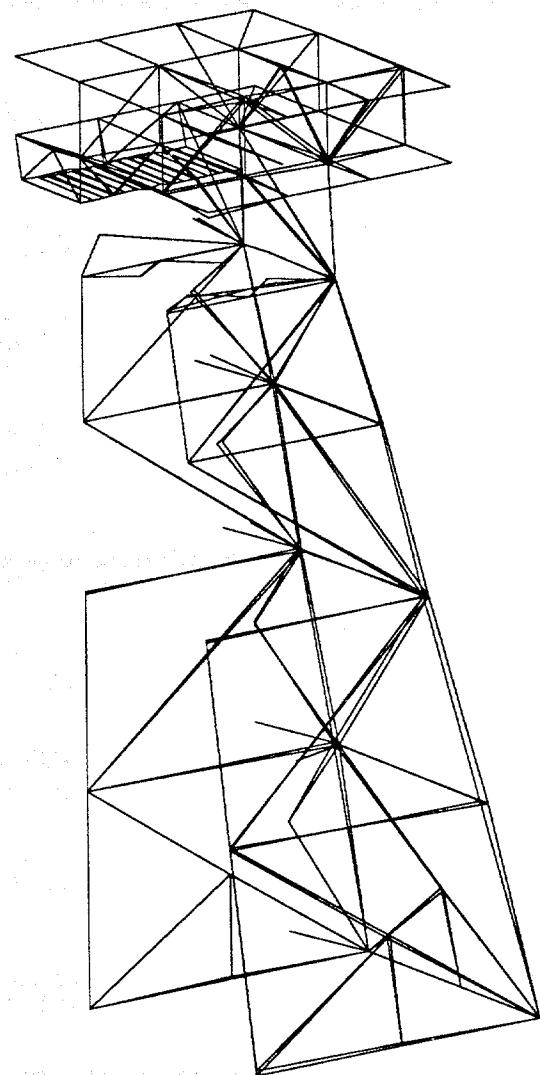


Figure 44 - Platform IRENE Fortysecond Mode - 10.66 Hz

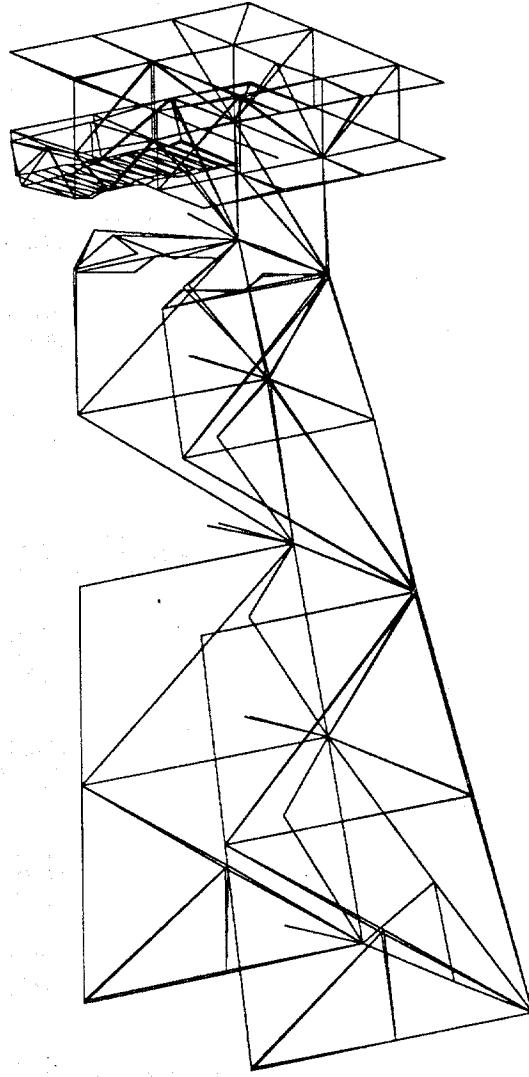


Figure 45 - Platform IRENE Fortyfifth Mode - 11.33 Hz

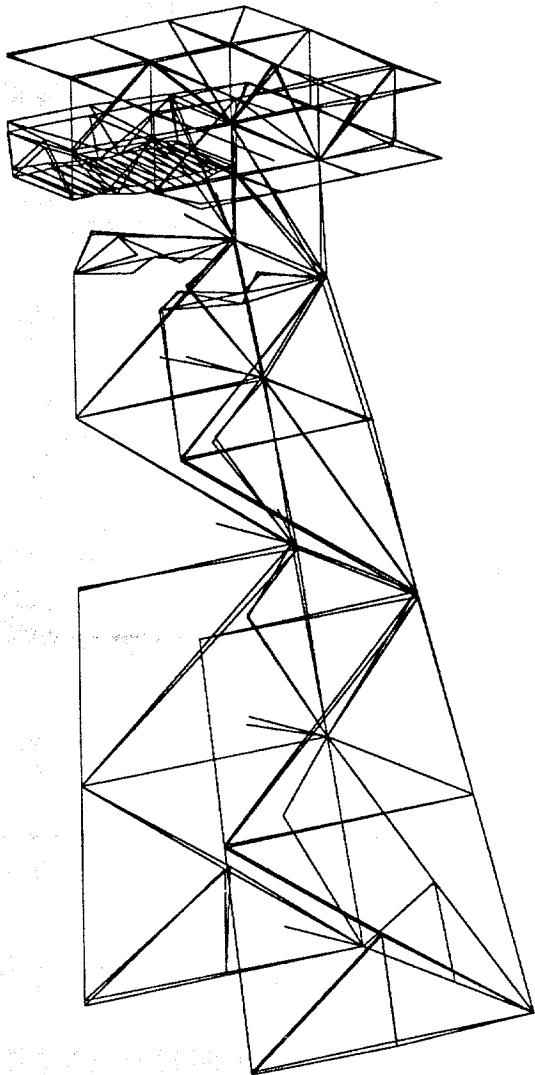


Figure 46 - Platform IRENE Fortysixth Mode - 11.42 Hz

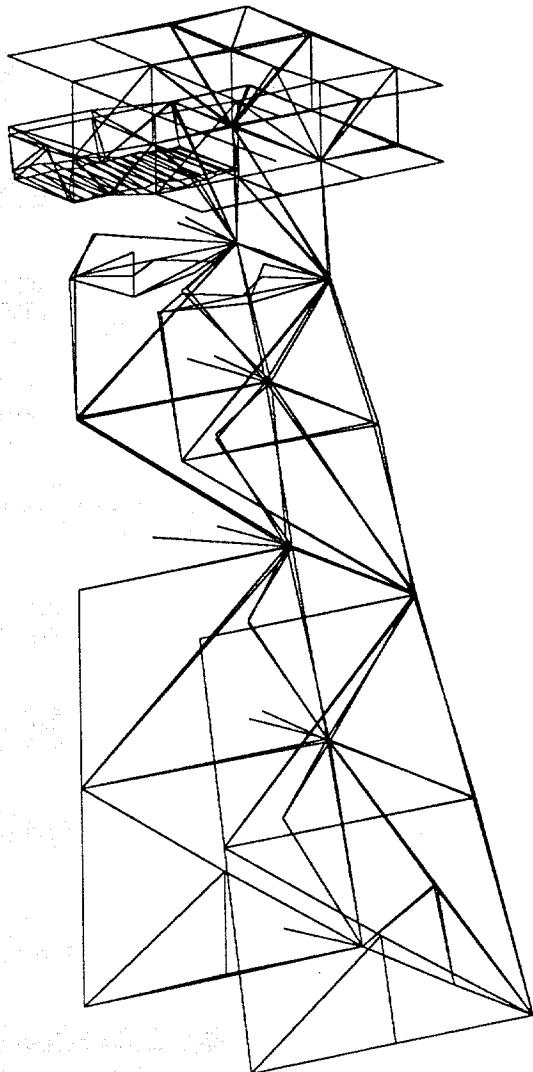


Figure 47 - Platform IRENE Forty-eighth Mode - 12.04 Hz

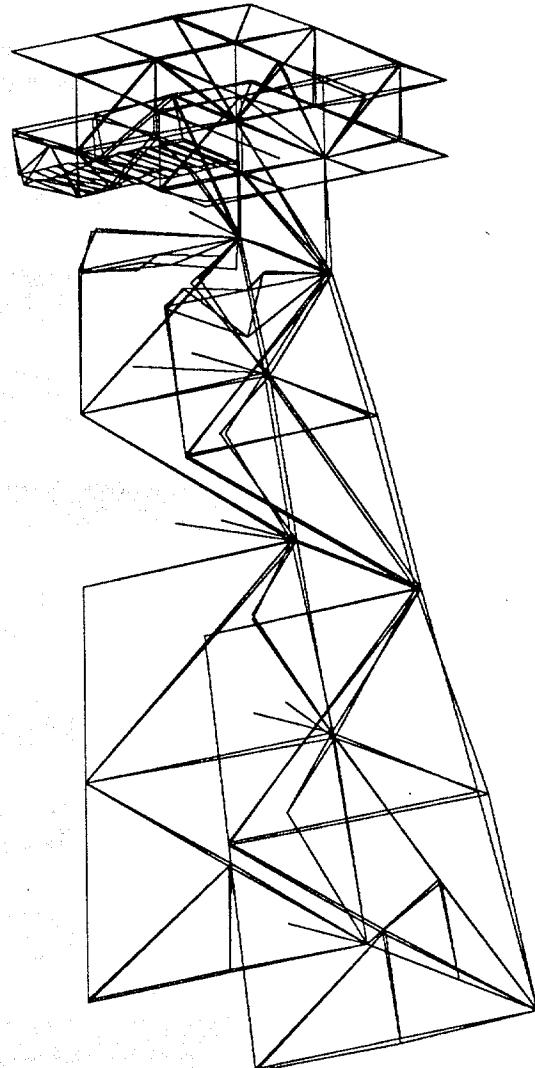


Figure 48 - Platform IRENE Fiftyfirst Mode - 12.29 Hz

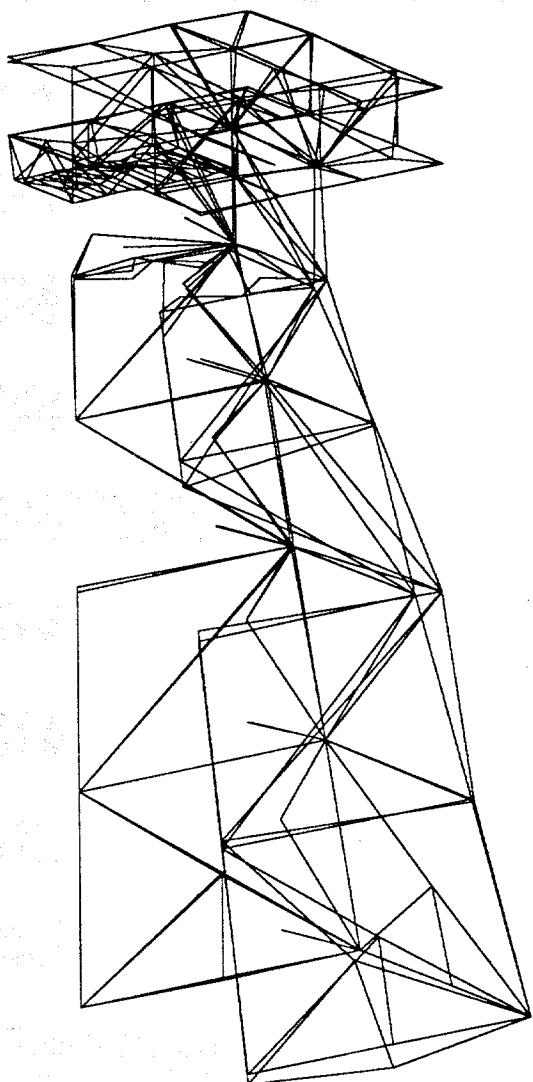


Figure 49 - Platform IRENE Fiftyeighth Mode - 14.37 Hz

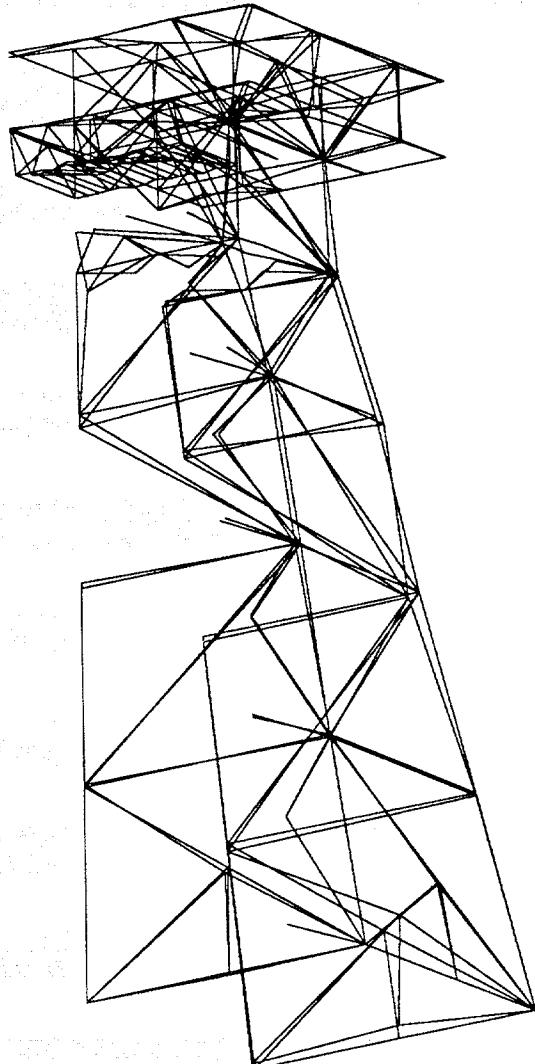


Figure 50 - Platform IRENE Fifty ninth Mode - 14.96 Hz

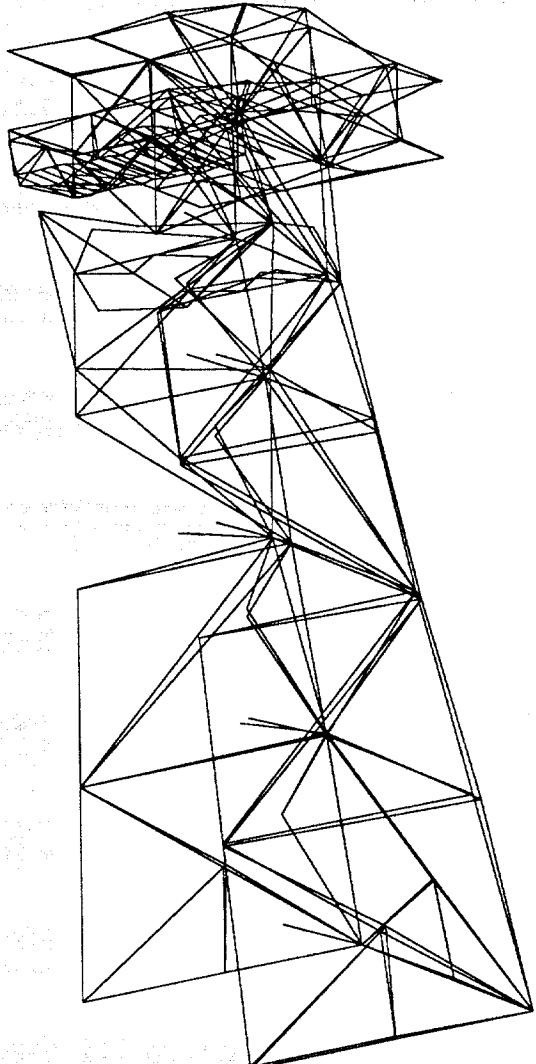
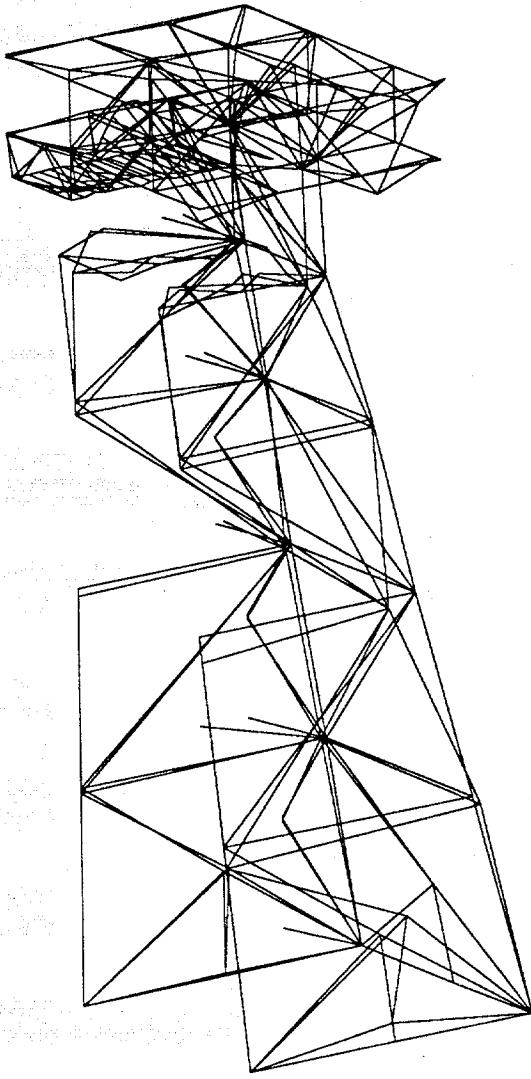
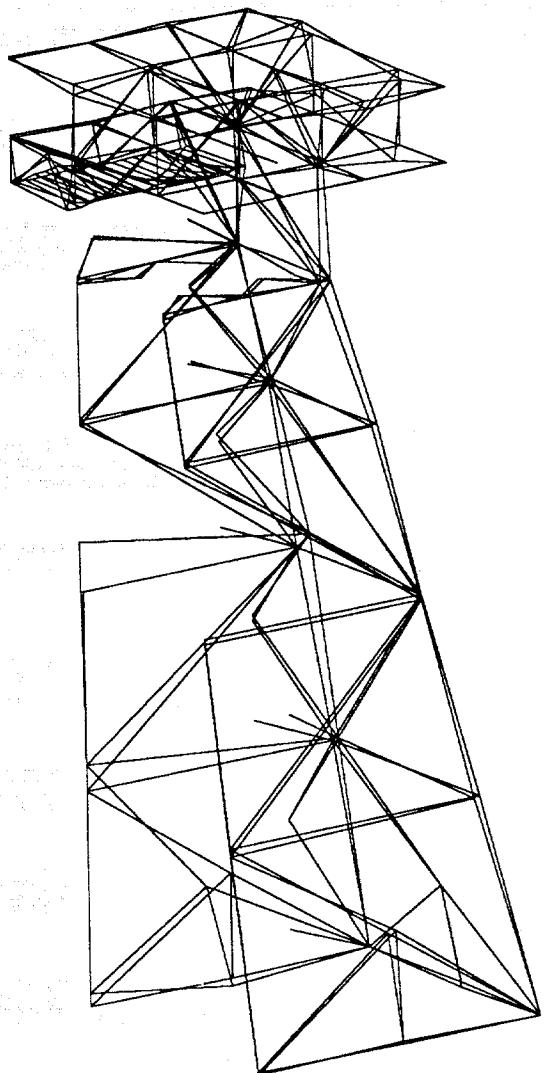


Figure 51 - Platform IRENE Sixtieth Mode - 15.49 Hz



**Figure 52 - Platform IRENE Sixtysecond Mode - 17.37 Hz**



**Figure 53 - Platform IRENE Sixtyfifth Mode - 18.85 Hz**

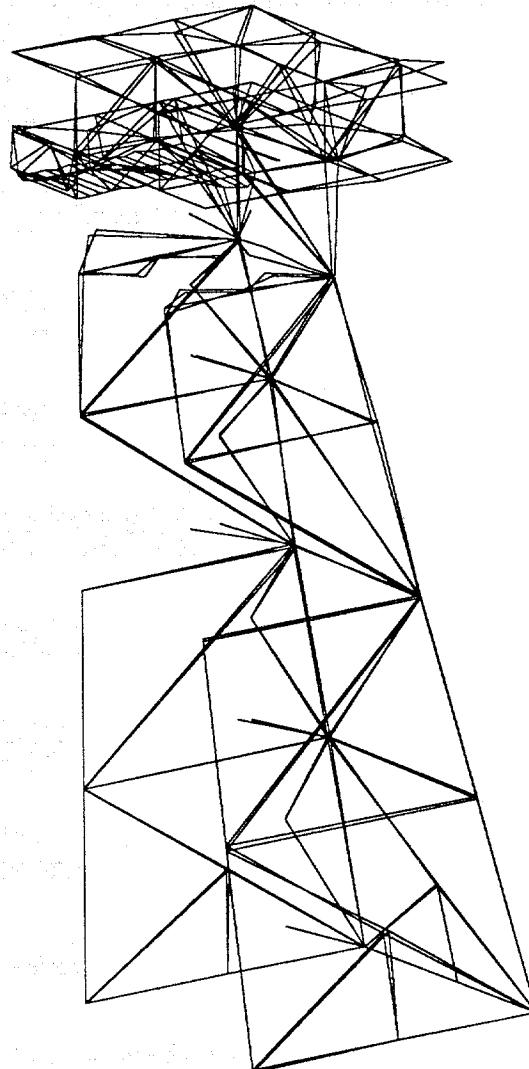


Figure 54 - Platform IRENE Sixtysixth Mode - 19.71 Hz

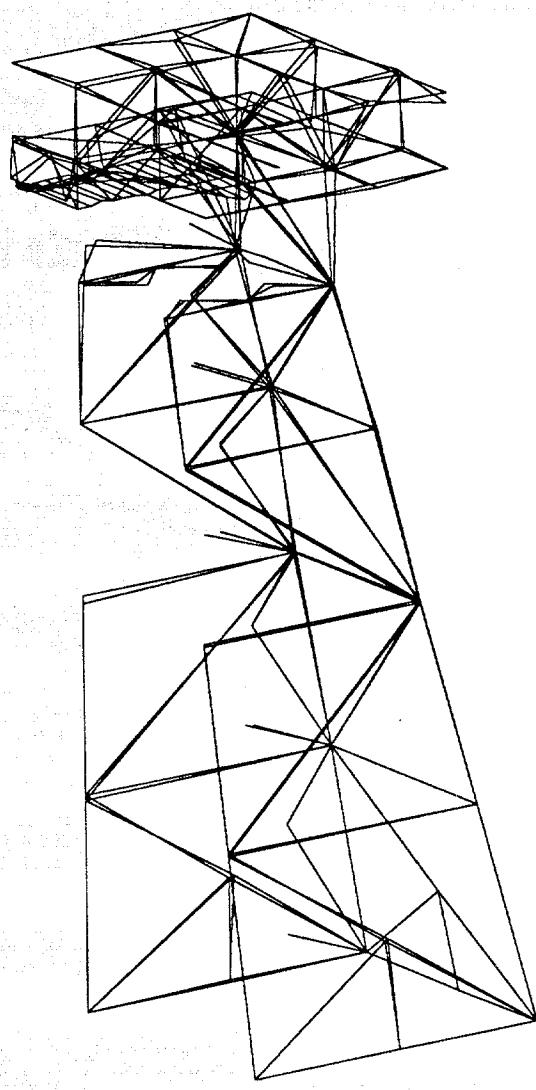


Figure 55 - Platform IRENE Sixtyseventh Mode - 19.79 Hz

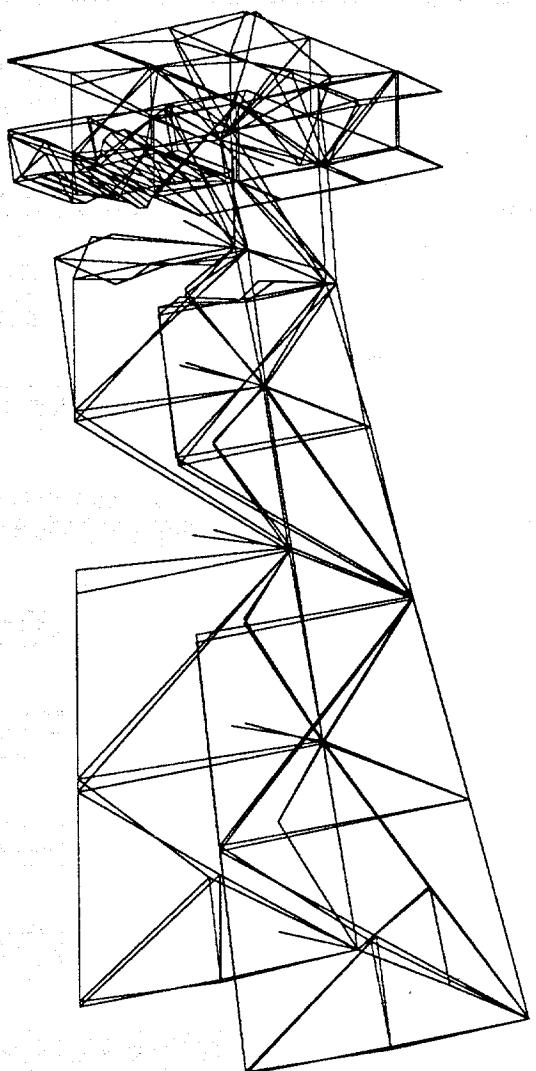


Figure 56 - Platform IRENE Sixtyeighth Mode - 19.98 Hz

Figure 57 Grid Point 345 Response to Random Excitation

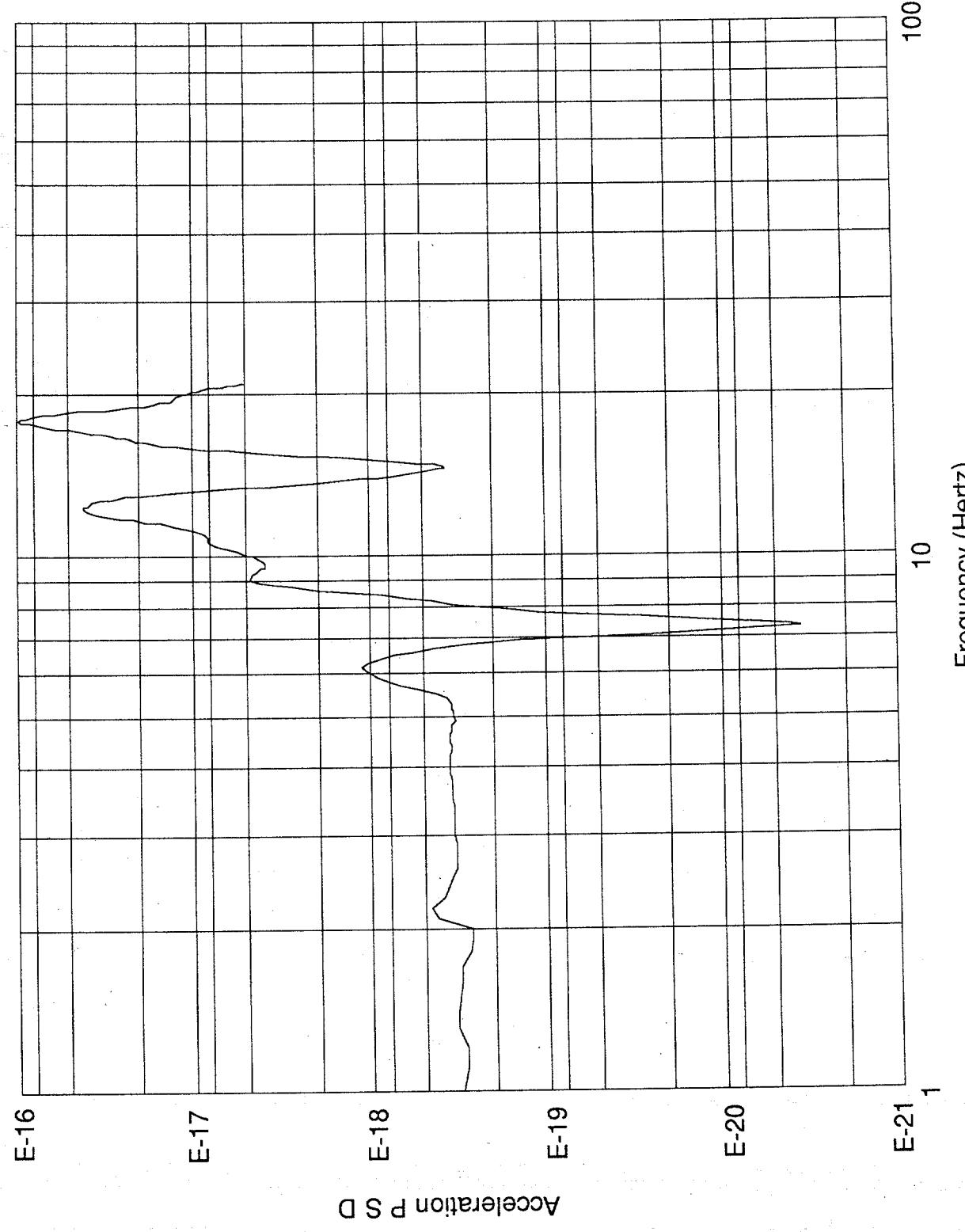


Figure 58 Grid Point 360 Response to Random Excitation

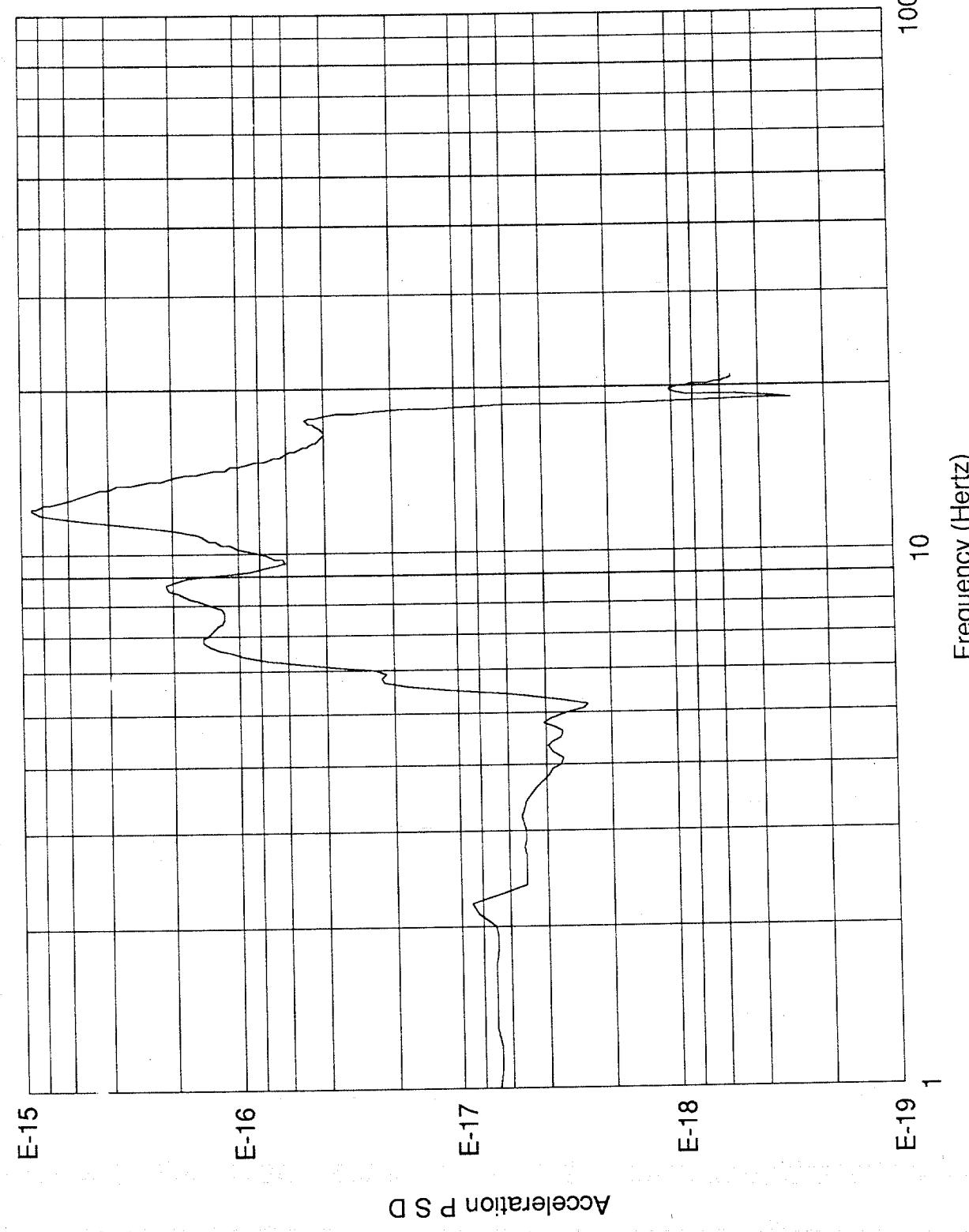


Figure 59 Grid Point 445 Response to Random Excitation

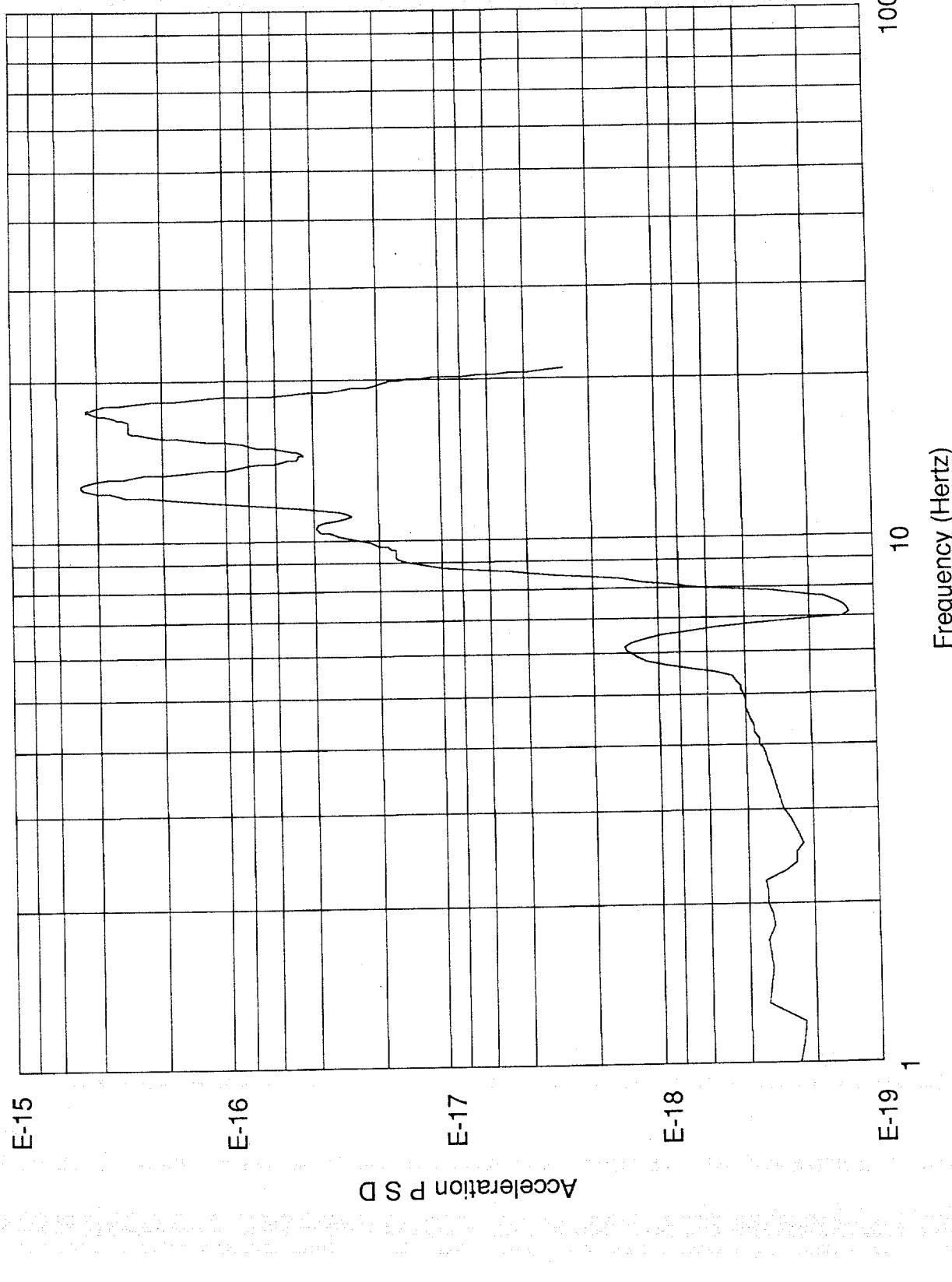


Figure 60 Grid Point 460 Response to Random Excitation

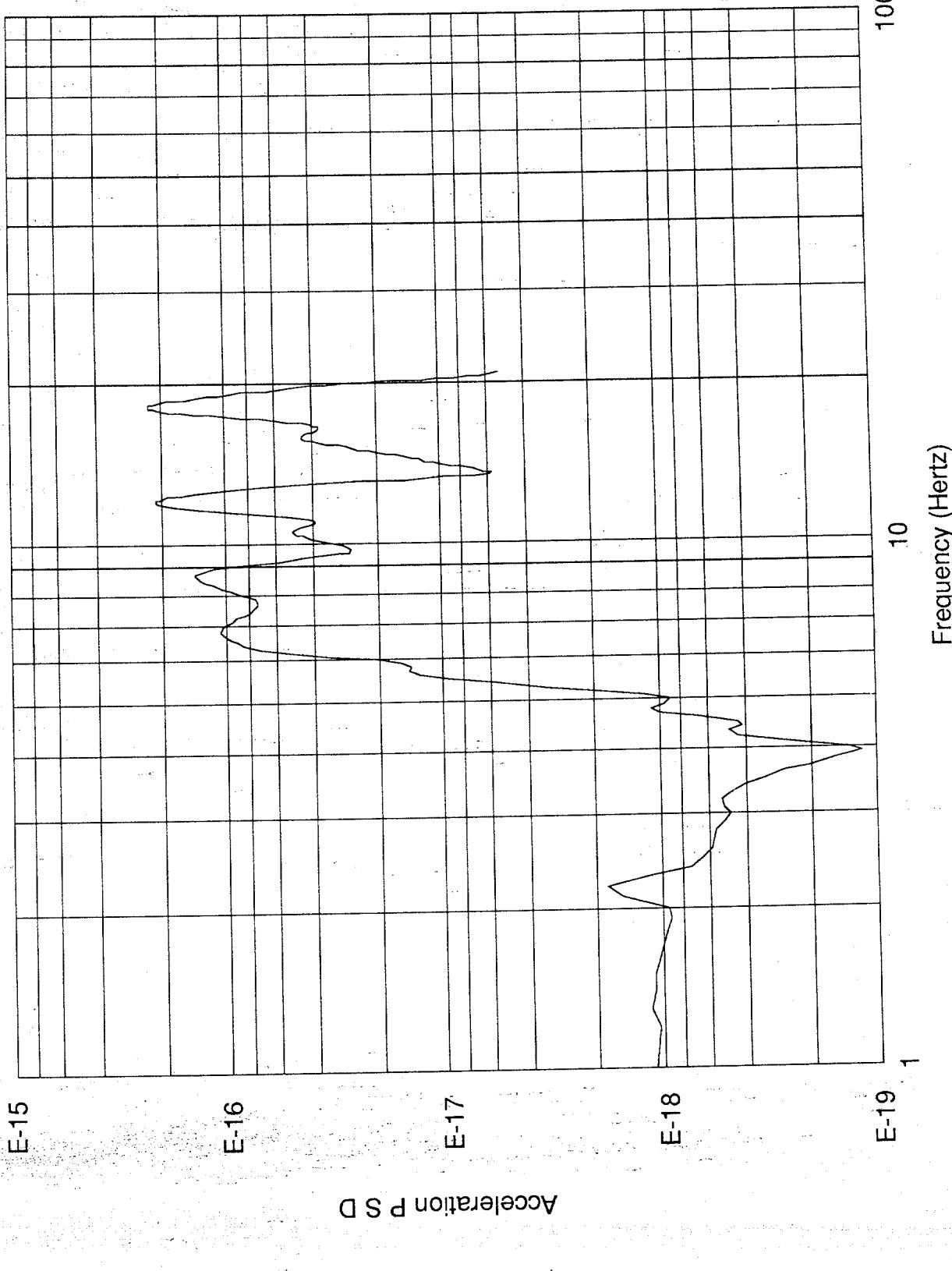


Figure 61 Grid Point 3000 Response to Random Excitation

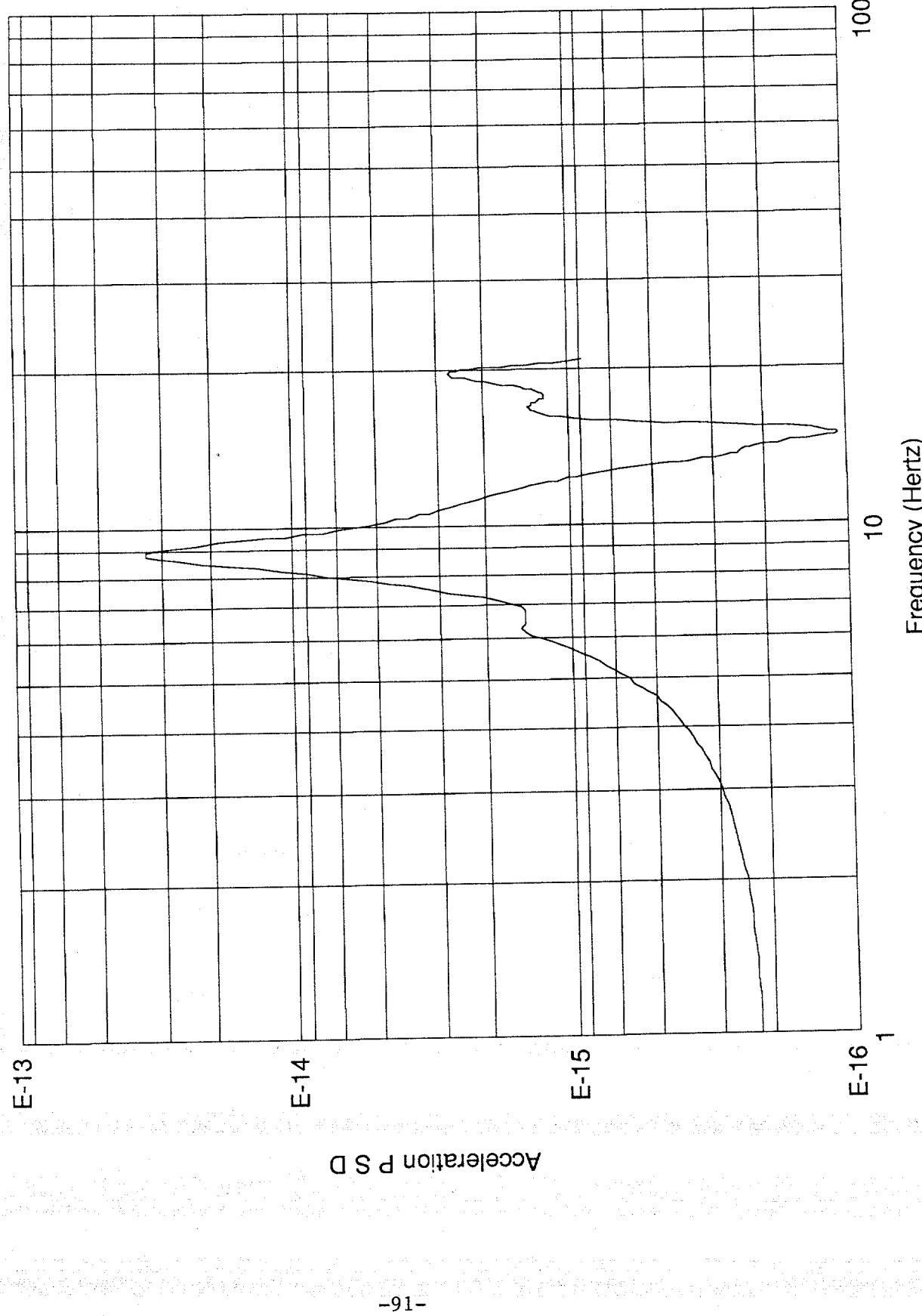


Figure 62 Grid Point 3025 Response to Random Excitation

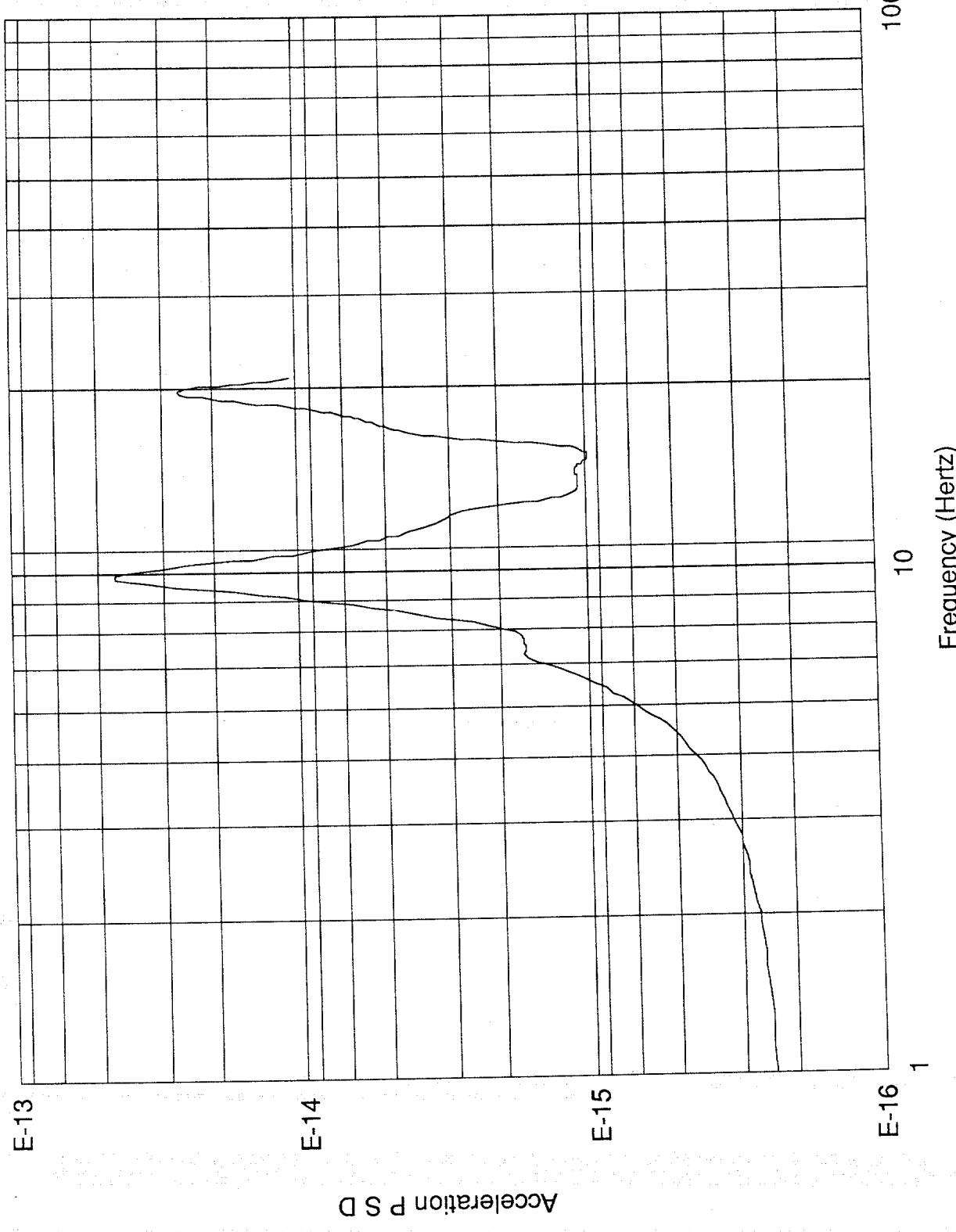


Figure 63 Grid Point 1325 Response to Random Excitation

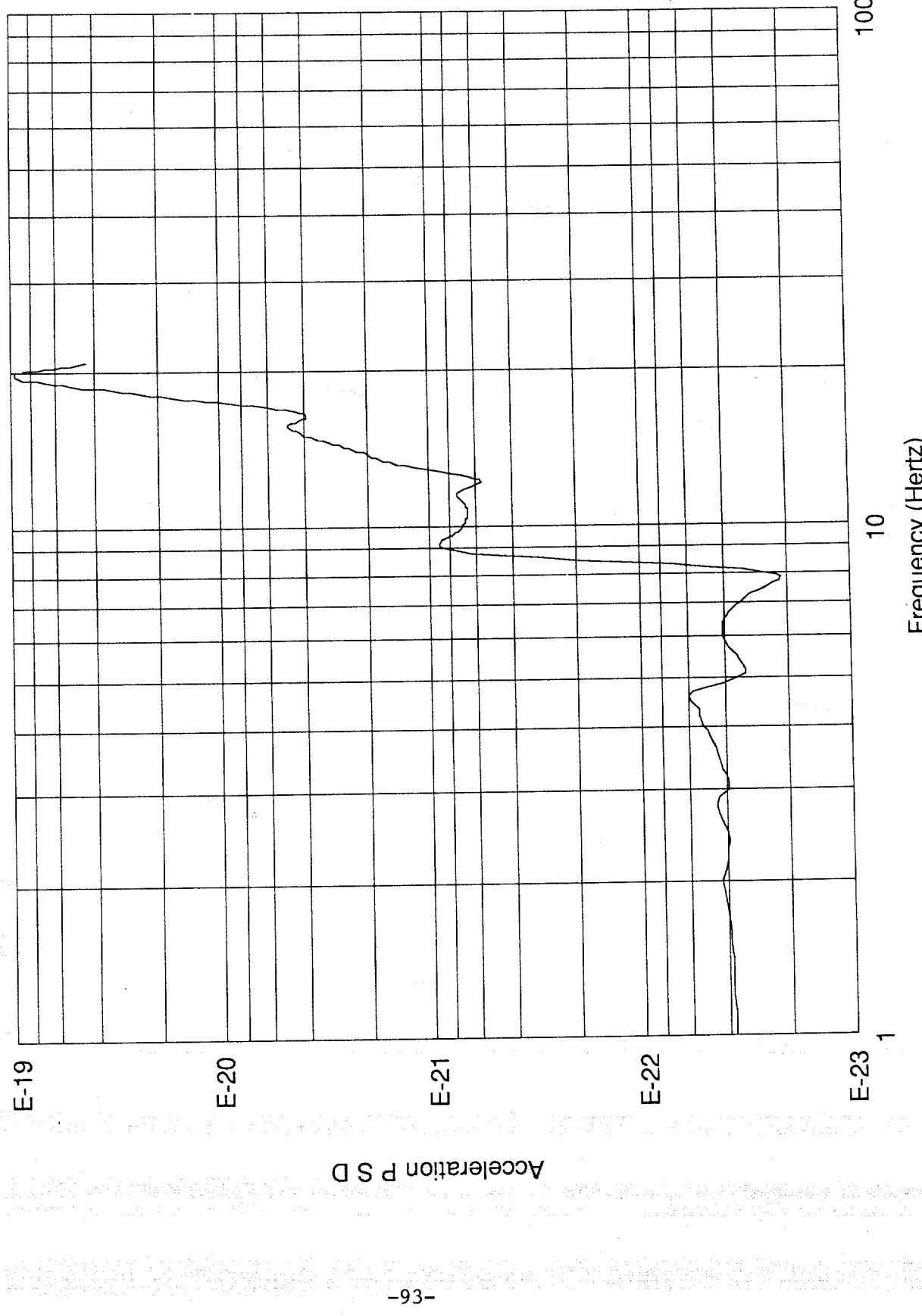


Figure 64 Grid Point 2325 Response to Random Excitation

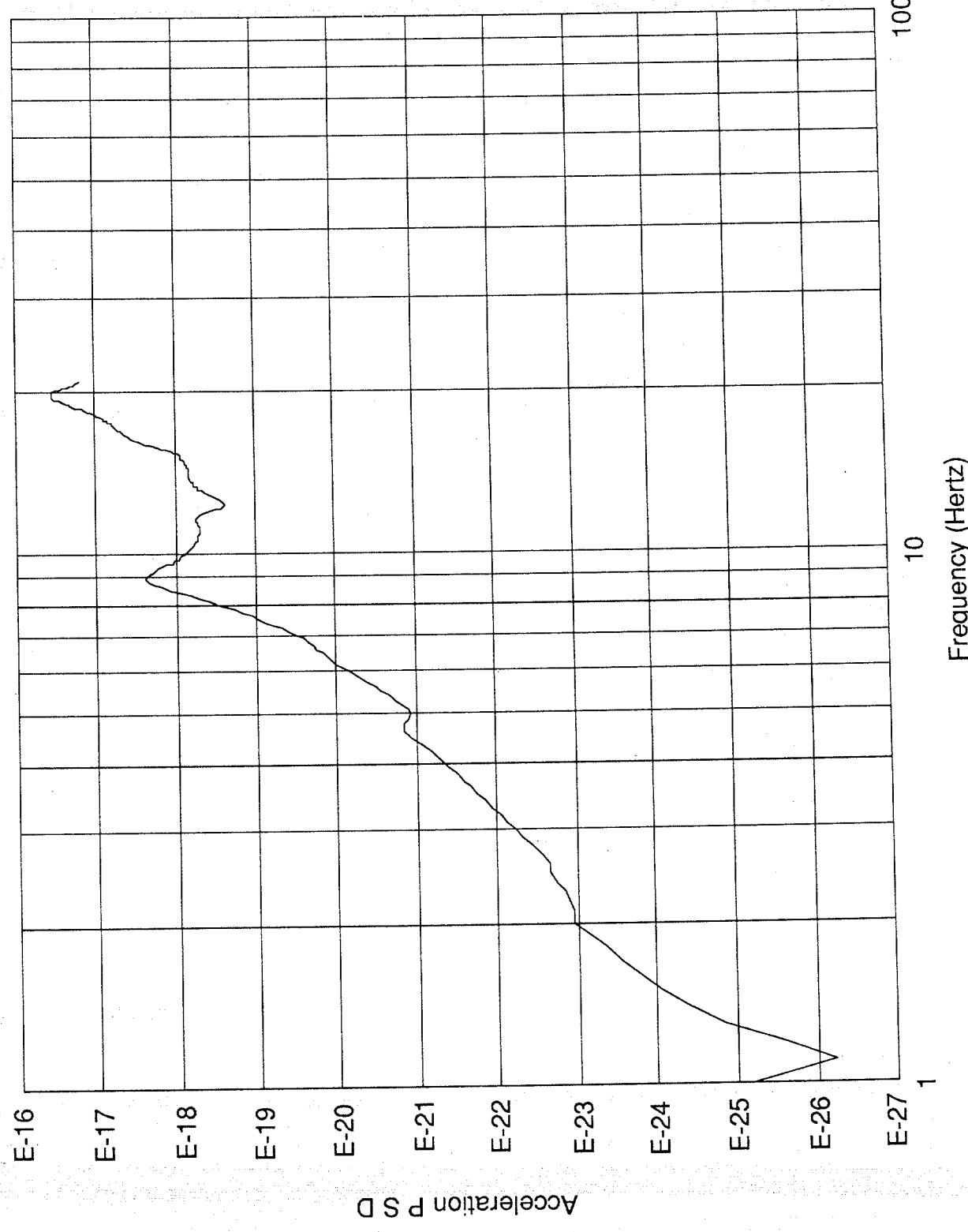


Figure 65 Grid Point 1615 Response to Random Excitation

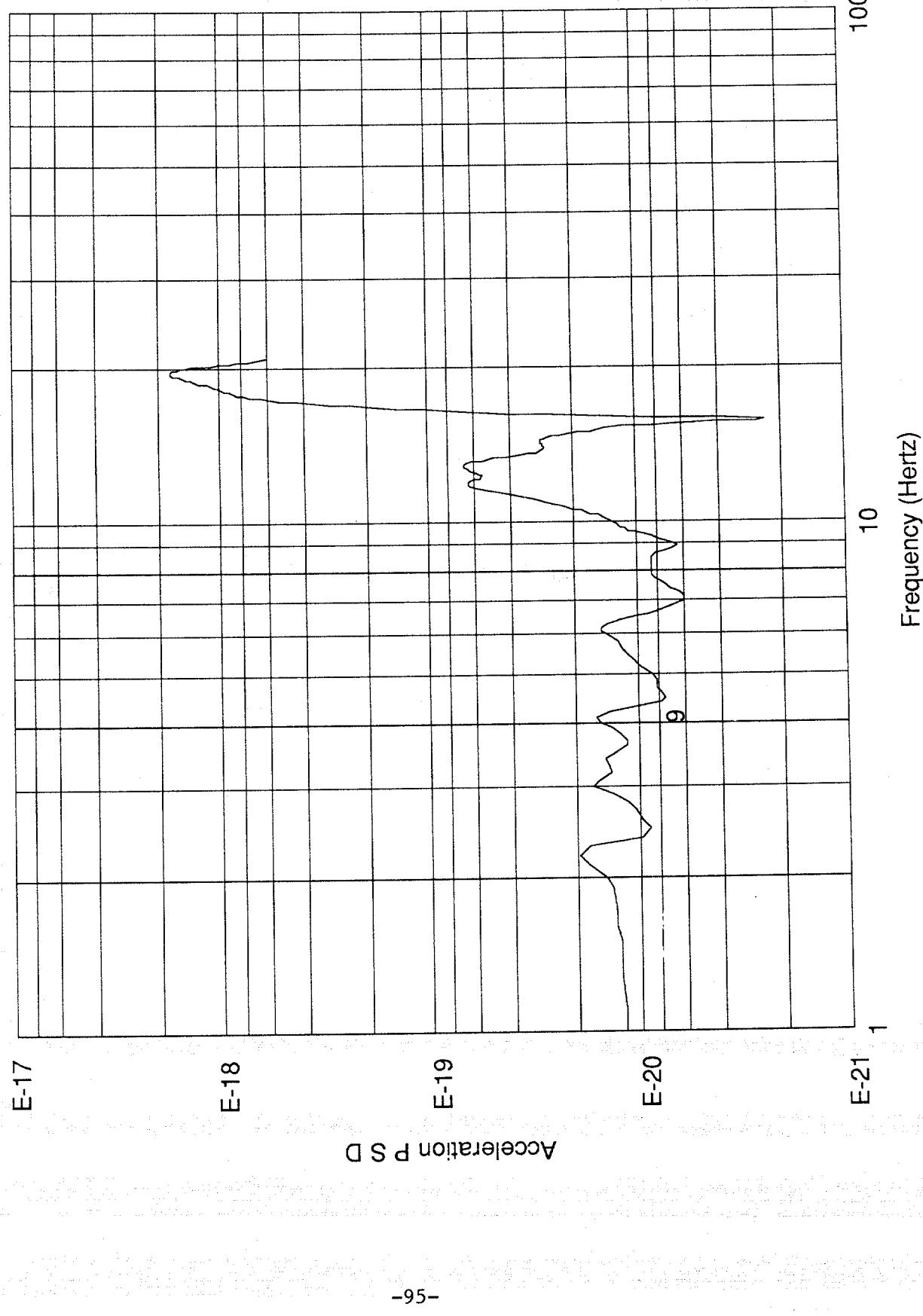


Figure 66 Grid Point 2615 Response to Random Excitation

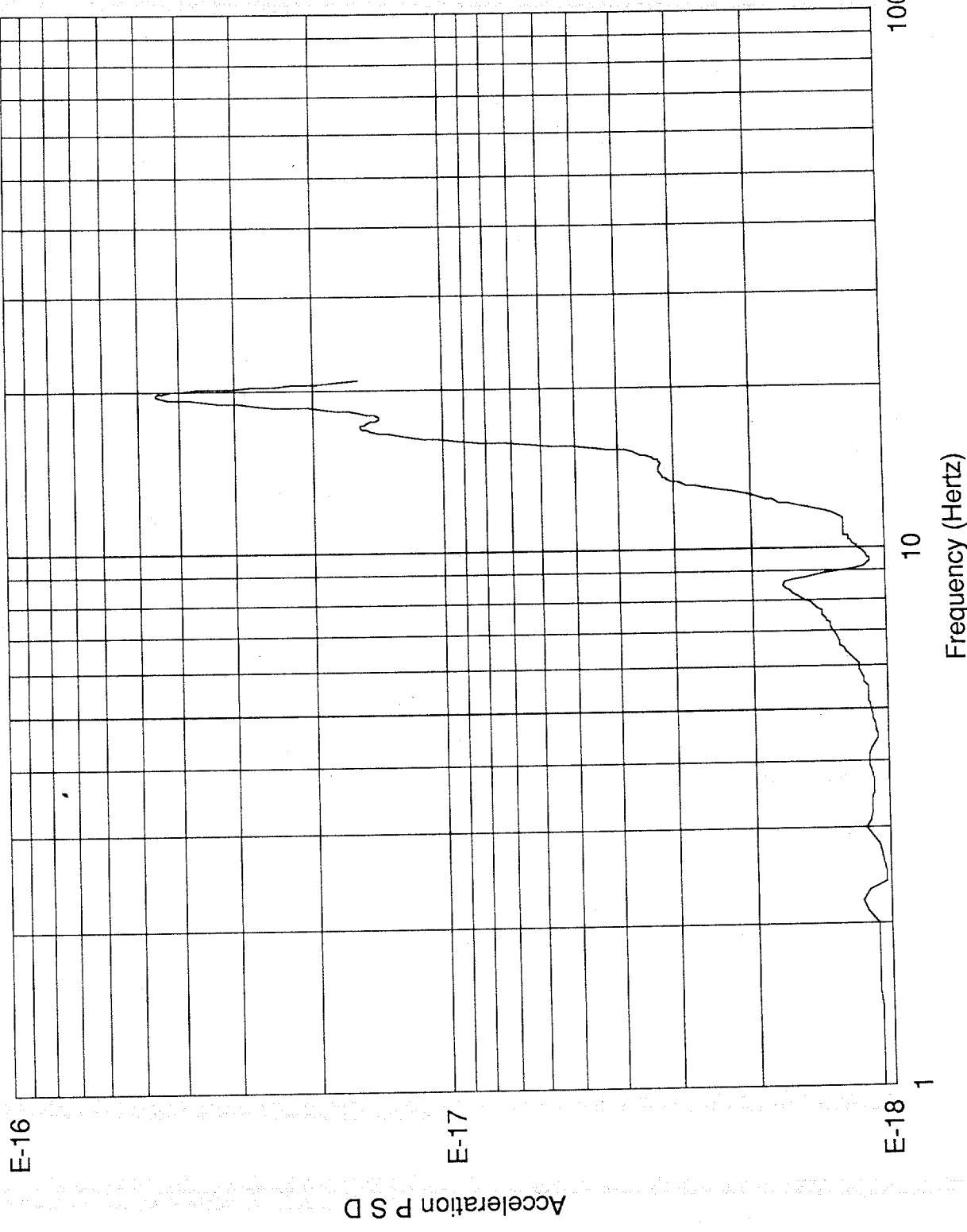


Figure 67 Grid Point 1510 Response to Random Excitation

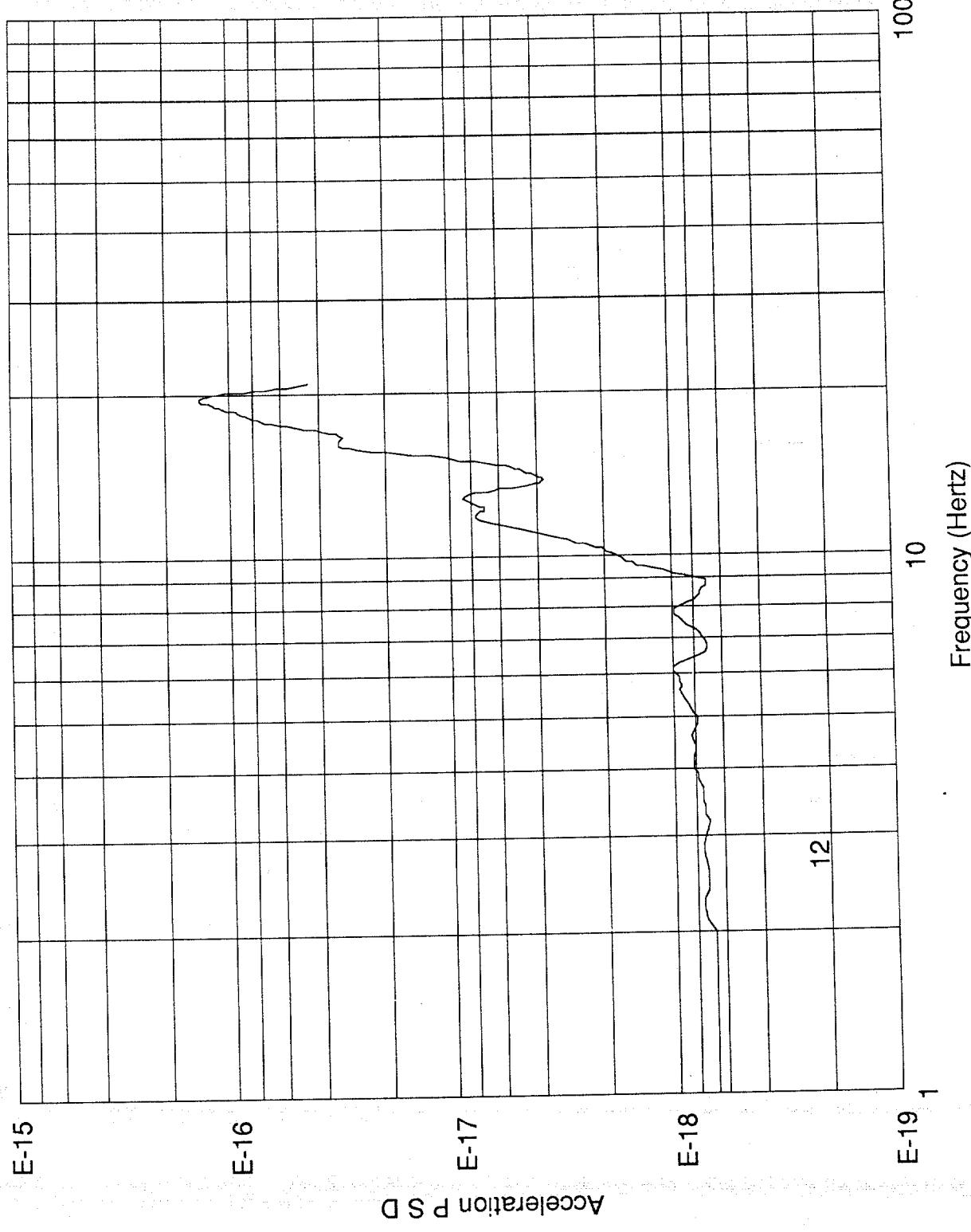


Figure 68 Grid Point 2510 Response to Random Excitation

